

**Figure 1. Sensor Placement Relative To Bit**

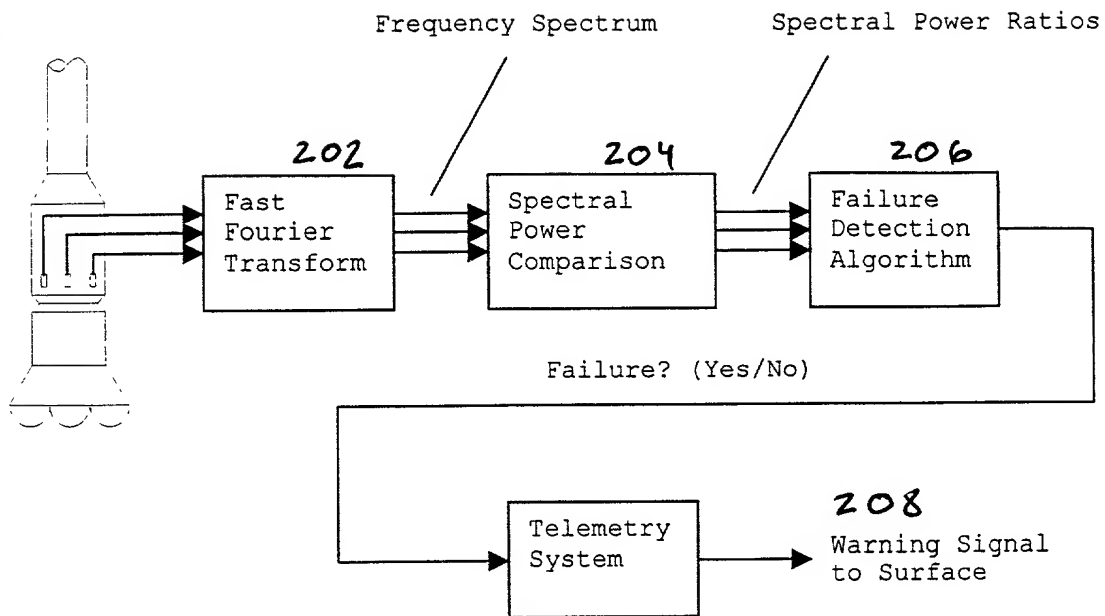
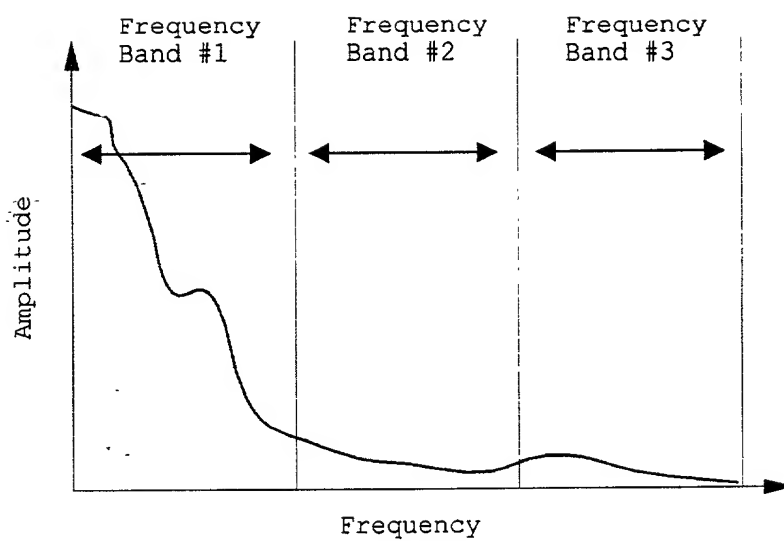


Figure 2



**Figure 3. Frequency Band Arrangement**

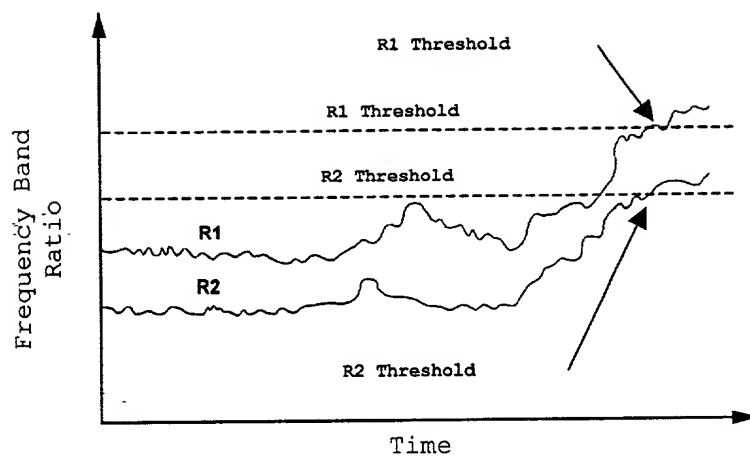
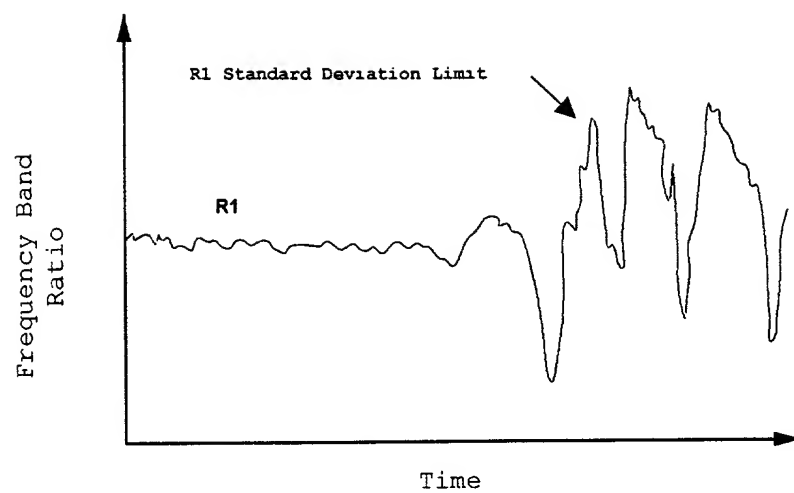


Figure 4. Threshold Failure Detection



**Figure 5 Statistical Failure Detection**

FOUO "SECRET"

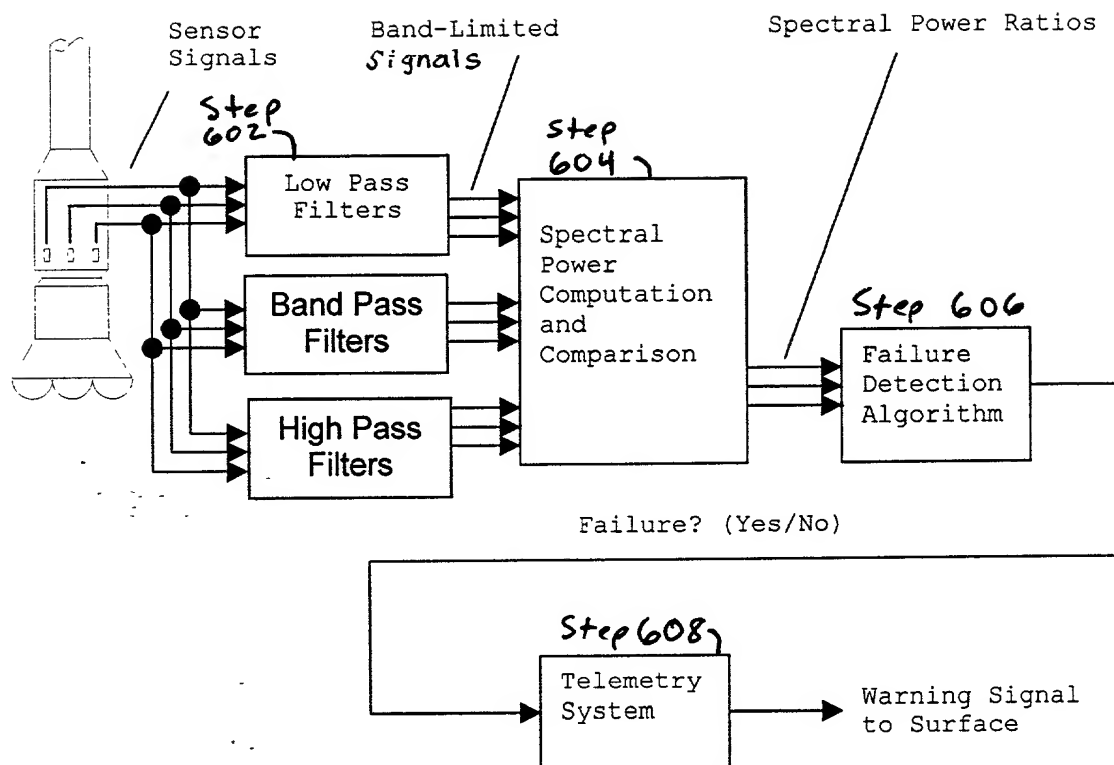


Figure 6 SPRA Method Using Analog Filters Spectral Power Separation

100360107

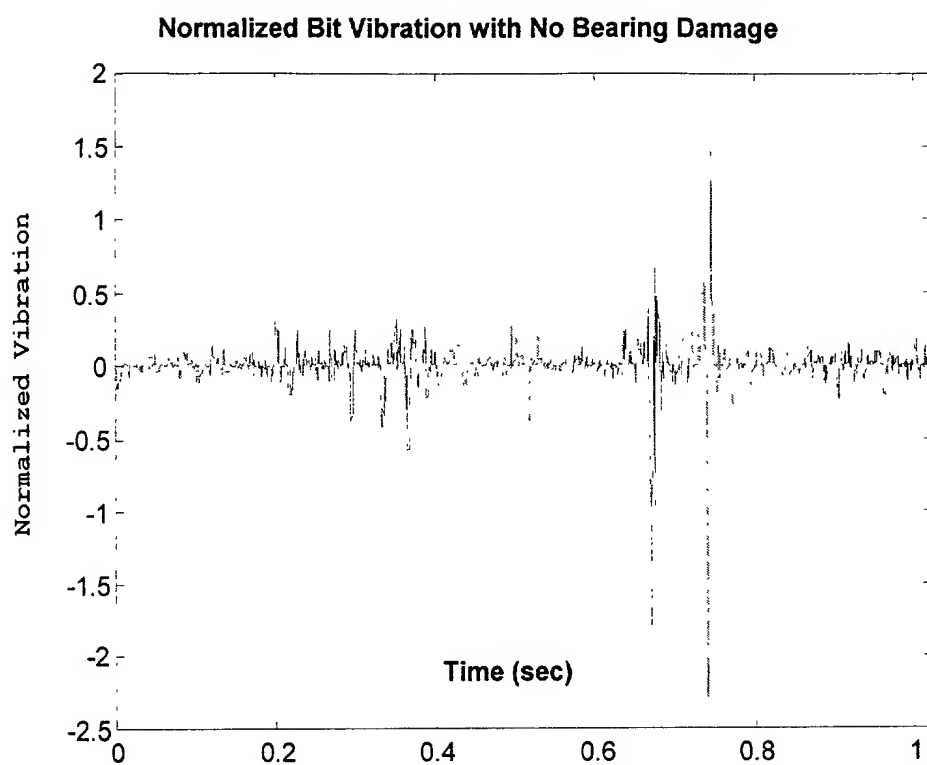


Figure 7.

# Discrete FFT of Vibration Data with No Bearing Damage

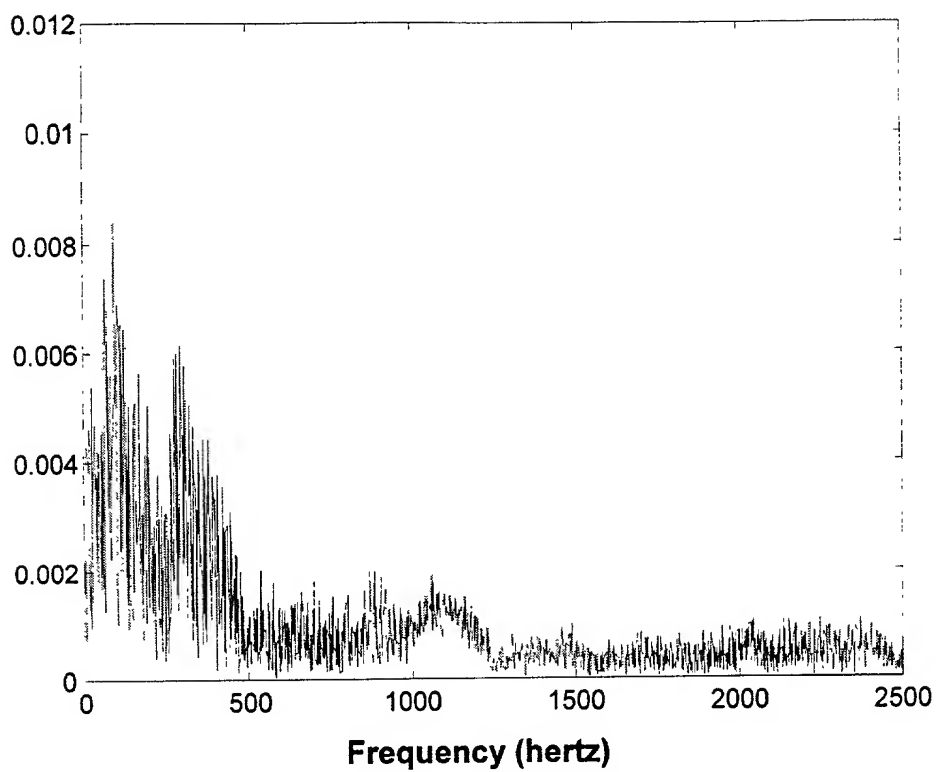


Figure 8.

10036405-101701  
TOTAL 507900F



## Spectral Power Analysis Bearing with No Damage

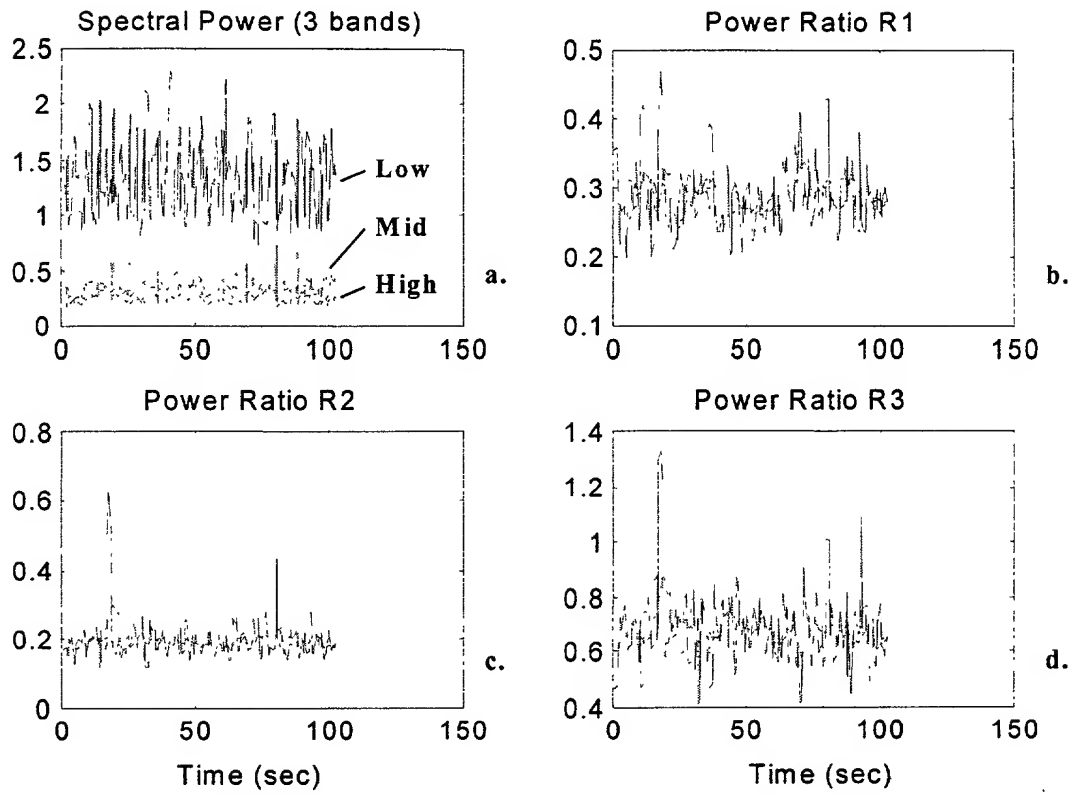


Figure 9.

100305-104701  
"FOZFOF" SOT3E00T

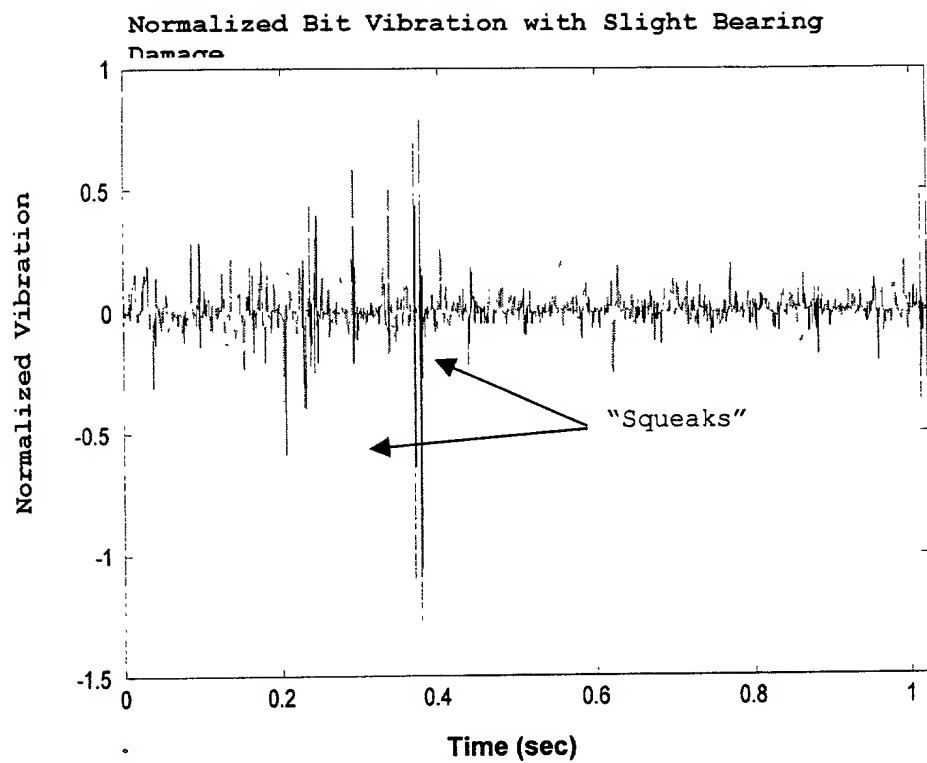


Figure 10.

# Discrete FFT of Vibration Data with Initial Bearing Damage

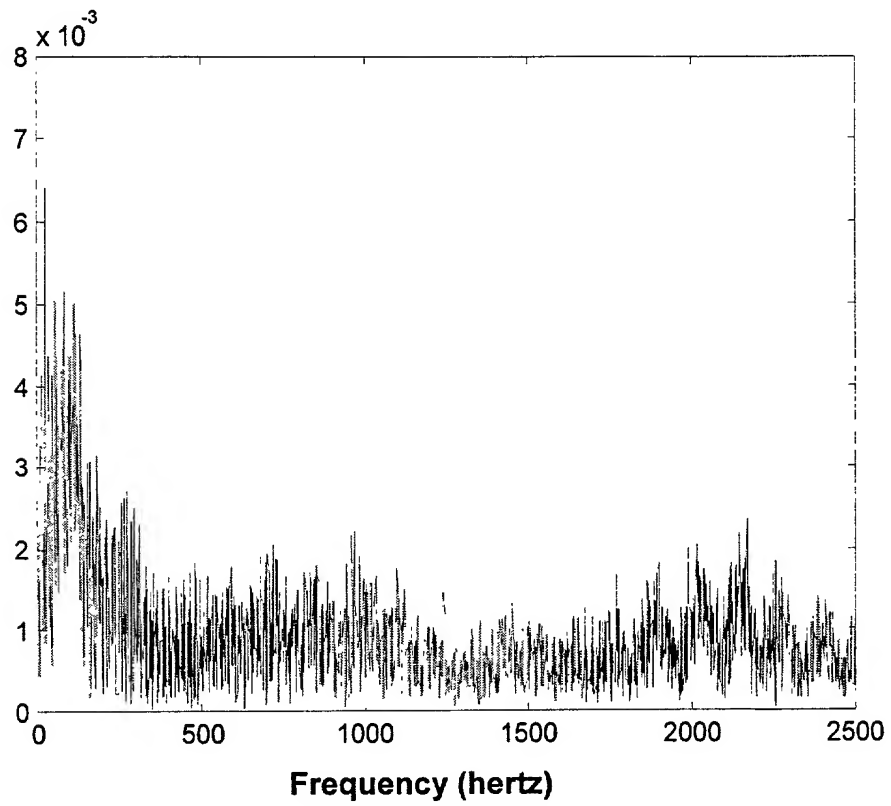


Figure 11.

10036105.101701  
10/27/01 5:07:50 PM

## Spectral Power Analysis for Slightly Damaged Bearing

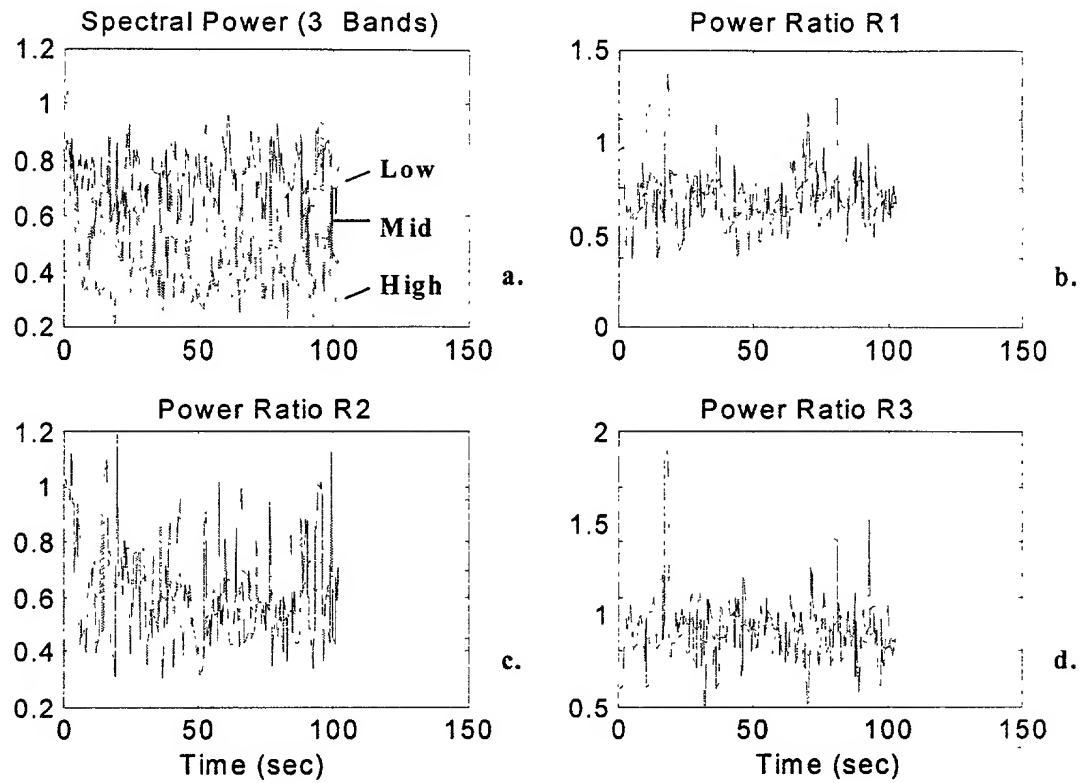


Figure 12.

## Normalized Bit Vibration with Moderate Bearing Damage

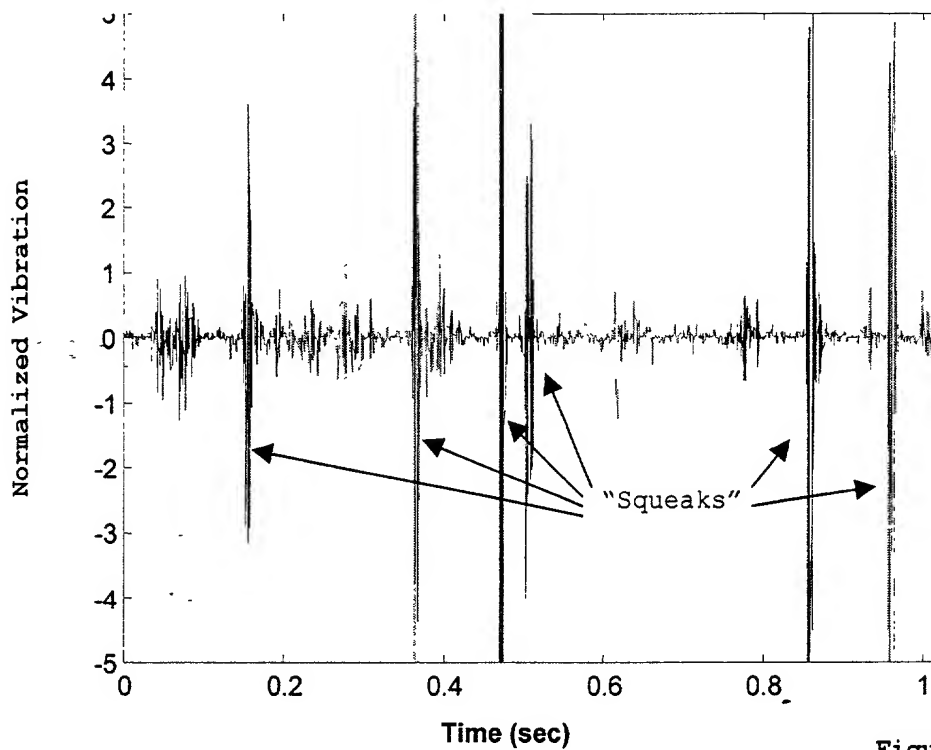


Figure 13.

# Discrete FFT of Vibration Data for Moderate Bearing Damage

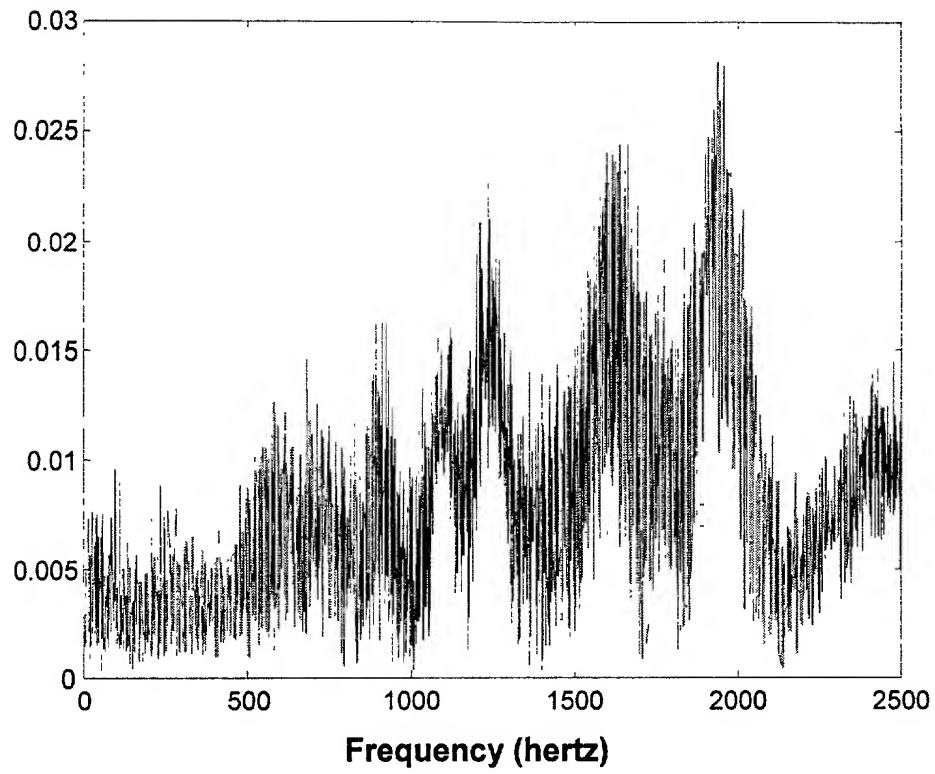


Figure 14.

10036103-10701  
FOI# 5079200

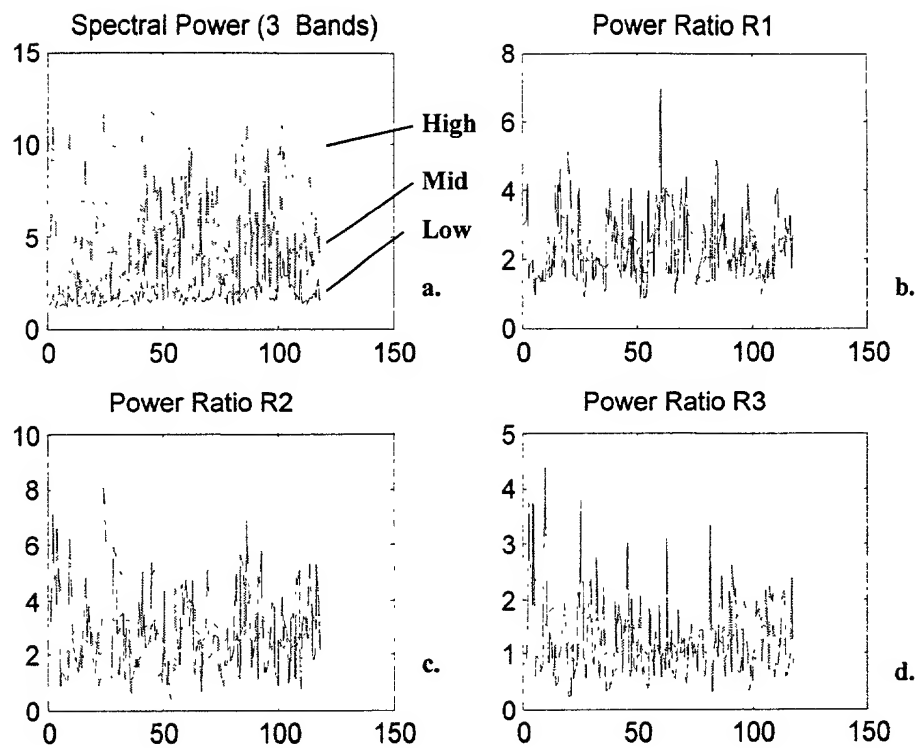
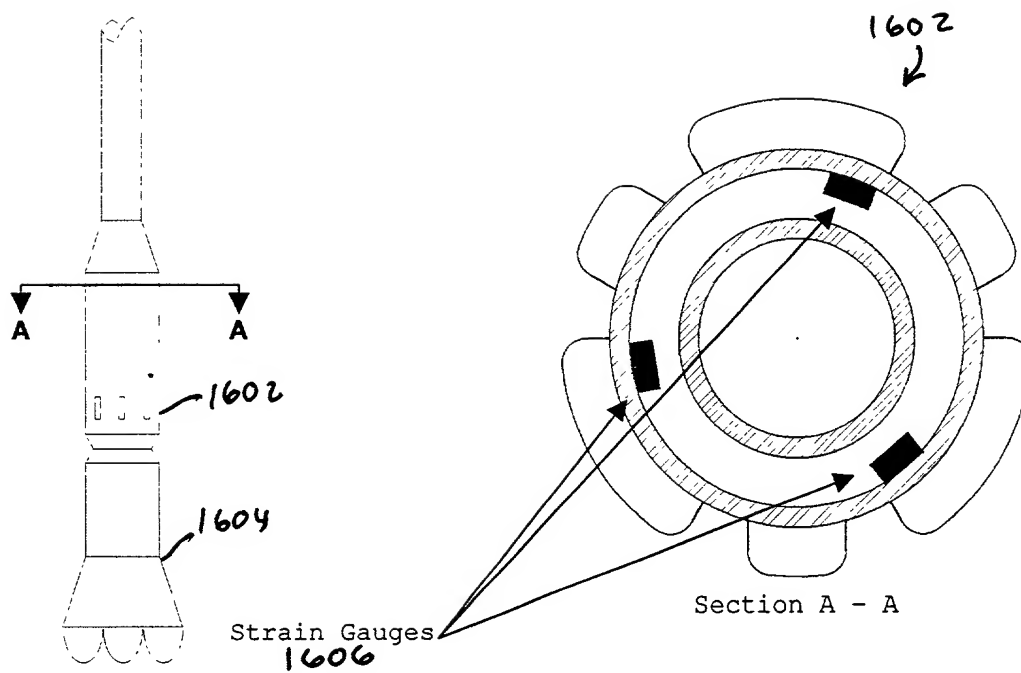
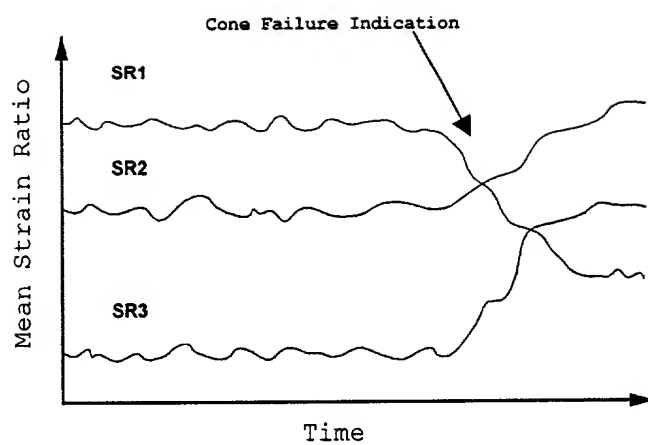


Figure 15.



**Figure 16. Strain Gauge Placement In Sensor Housing**



**Figure 17. Failure Indication (MSRA Method)**



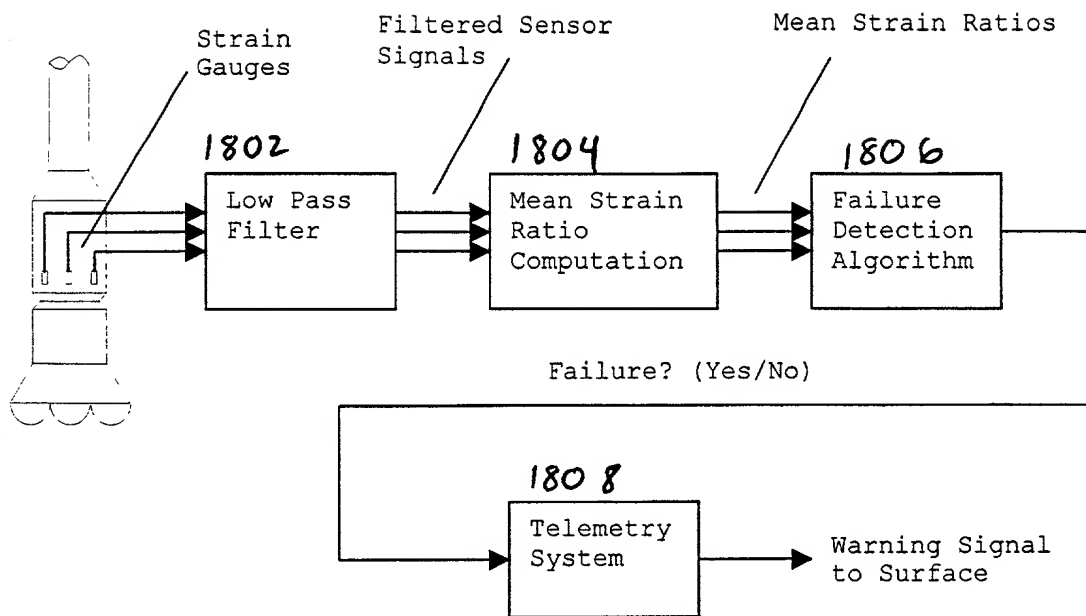


Figure 18. Schematic of MSRA Failure Detection Scheme

# Strain Gauge for No Bearing Damage

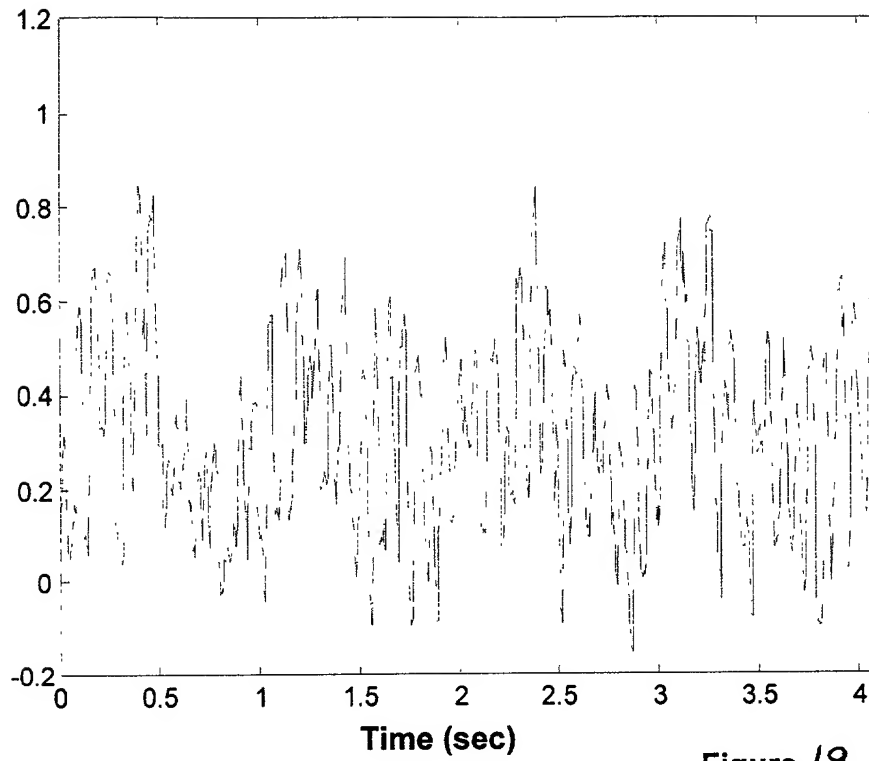


Figure 19

Discrete FFT of Strain Gauge Signal for No Bearing Damage

10036105-101701

# Discrete FFT of Strain Gauge Signal for No Bearing Damage

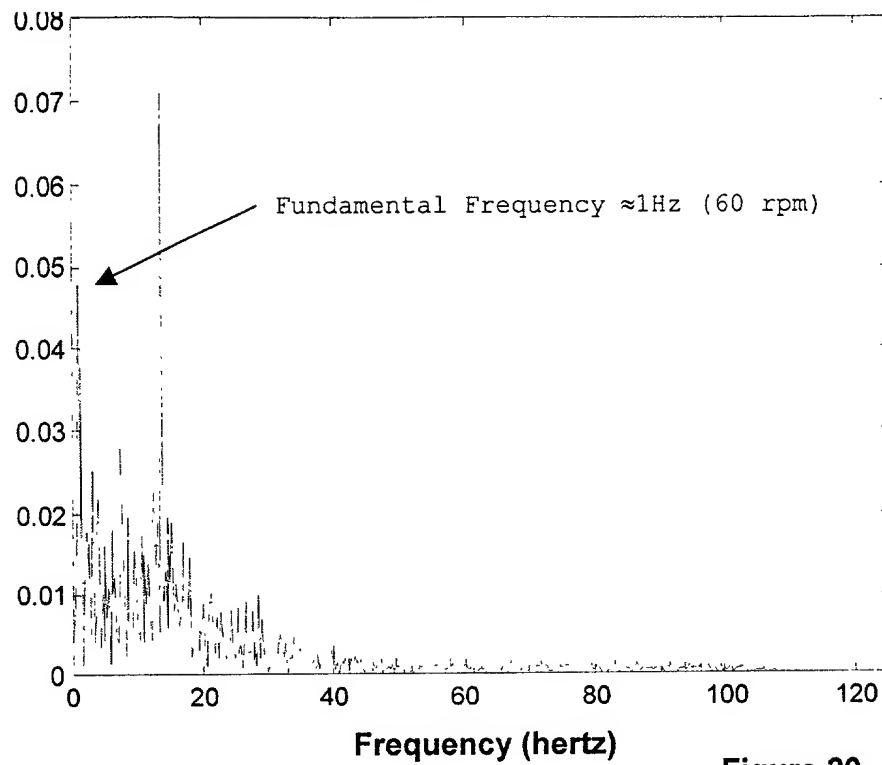


Figure 20.

Mean Strain Analysis for Bearing with No Damage

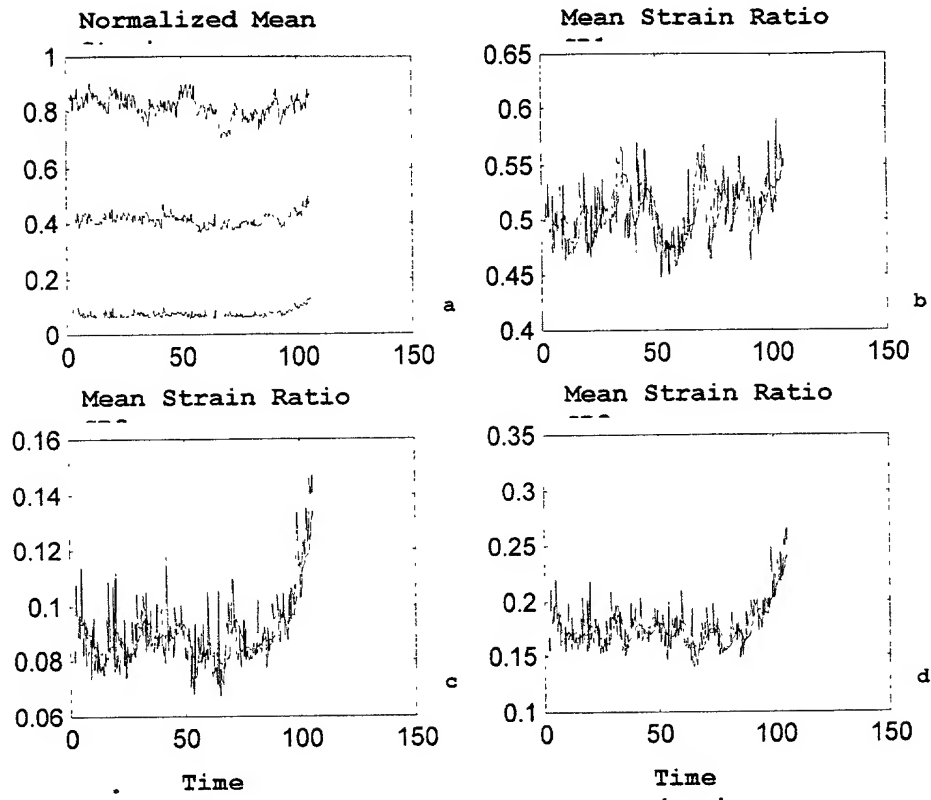


Figure 21.

10036105-10101

# Strain Gauge Signal when Bearing Lightly Damaged

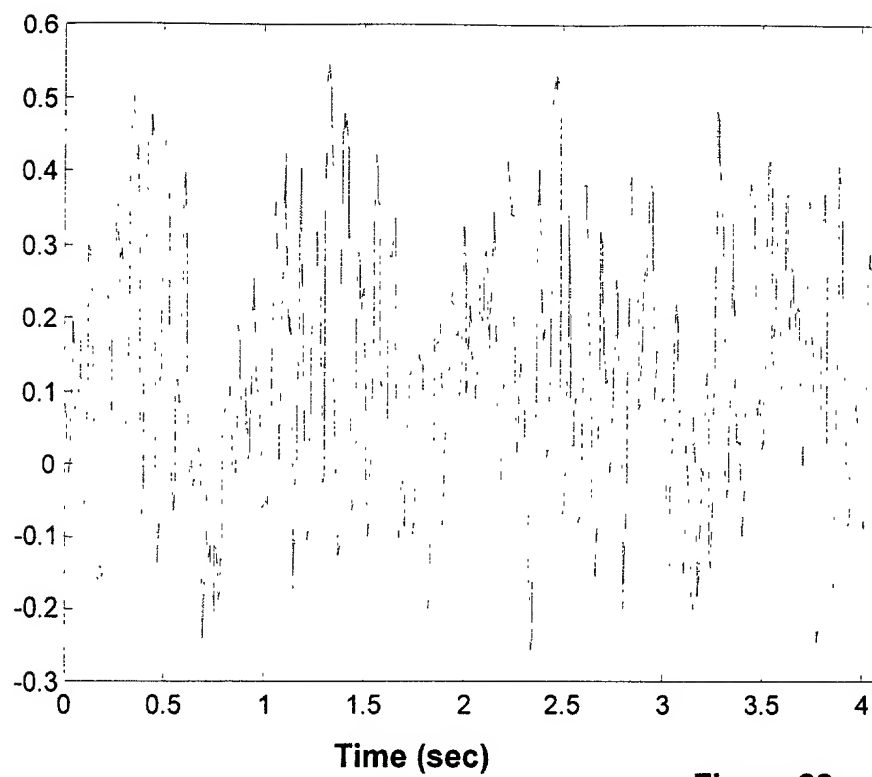


Figure 22.

10036105-10101  
T02T0T"50T500T

# Discrete FFT of Strain Gauge Signal for Light Bearing Damage

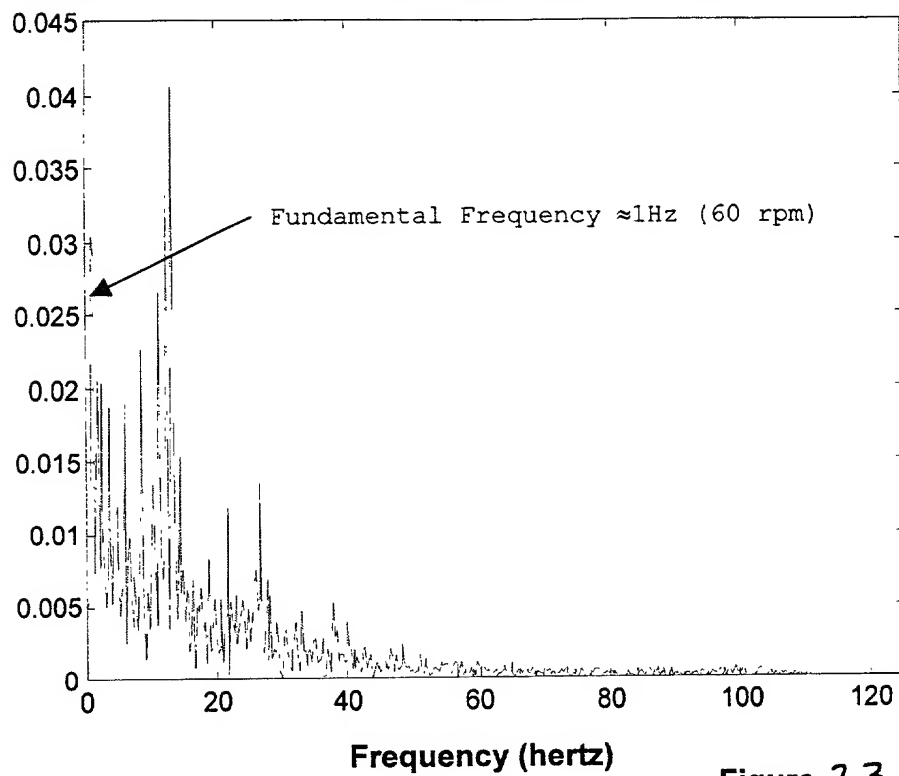


Figure 23

10036105-10701  
FOUO "SOTSE00T"

Mean Strain Analysis for Bearing with Light Damage

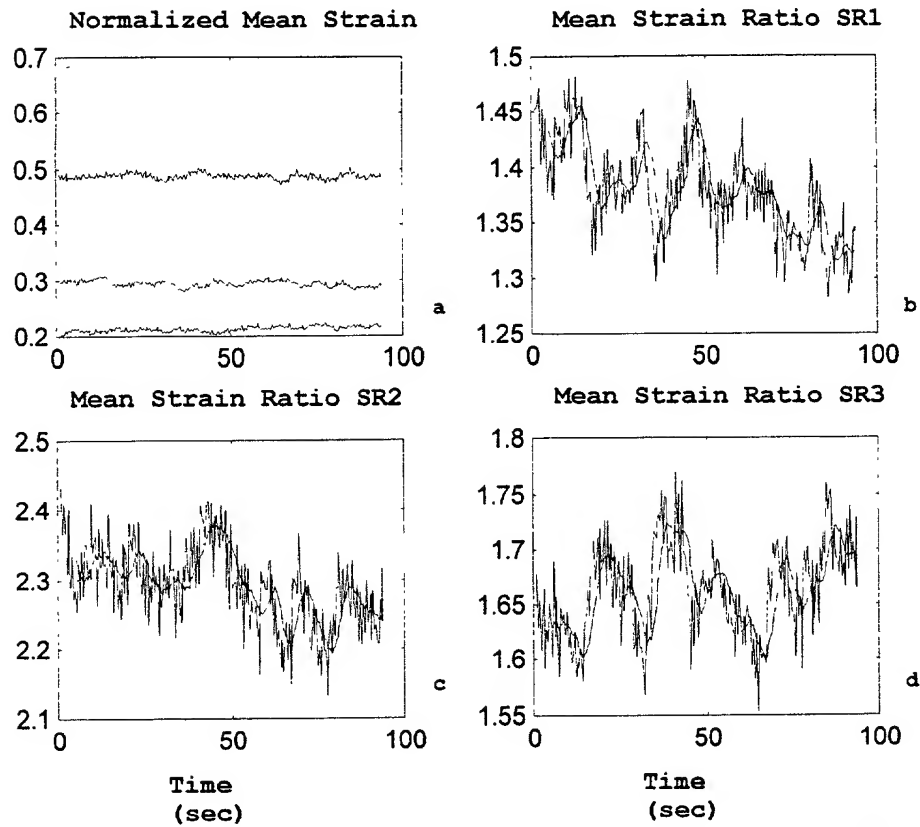
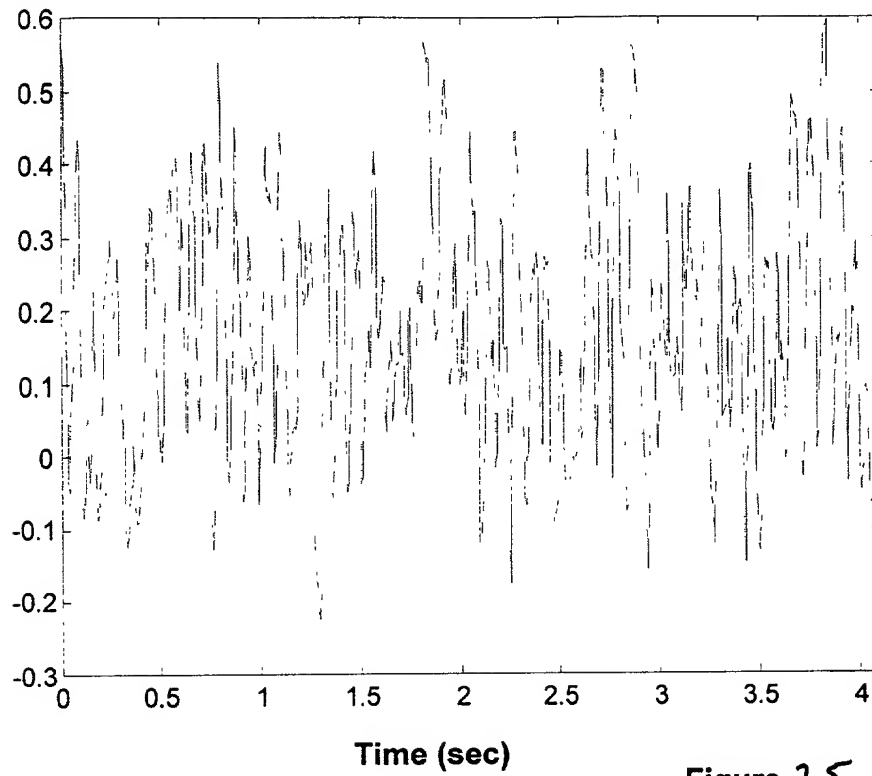


Figure 24

100305-10101  
FOUO "SECRET"

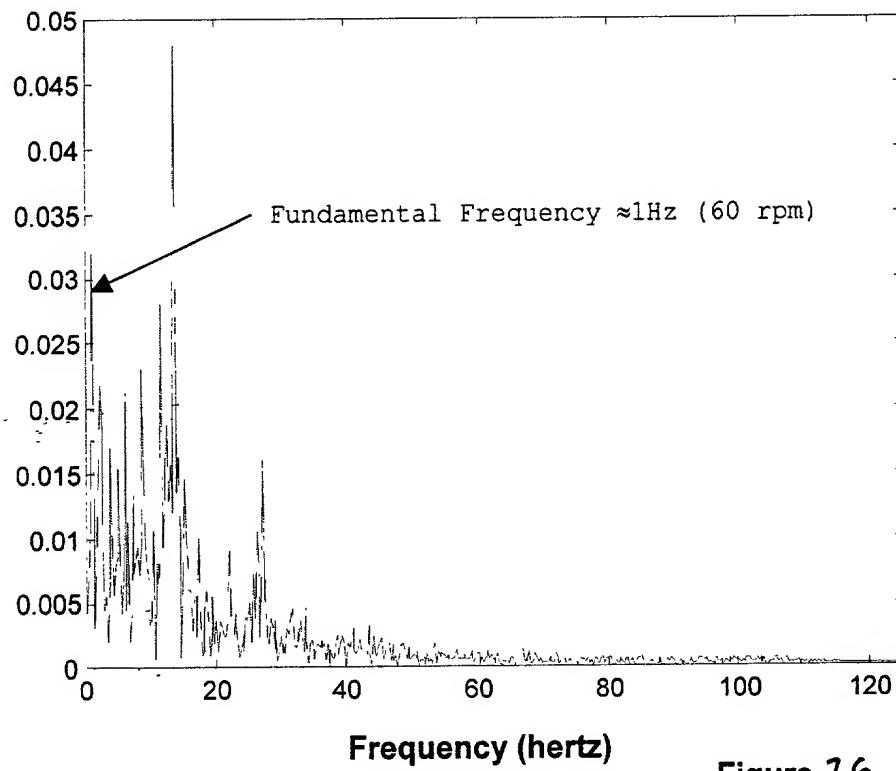
FOI 5019001

**Strain Gauge Signal when Bearing Moderately Damaged**



**Figure 25**

**Discrete FFT of Strain Gauge Signal for Moderate Bearing Damage**



**Figure 26**



## Mean Strain Analysis for Bearing with Moderate Damage

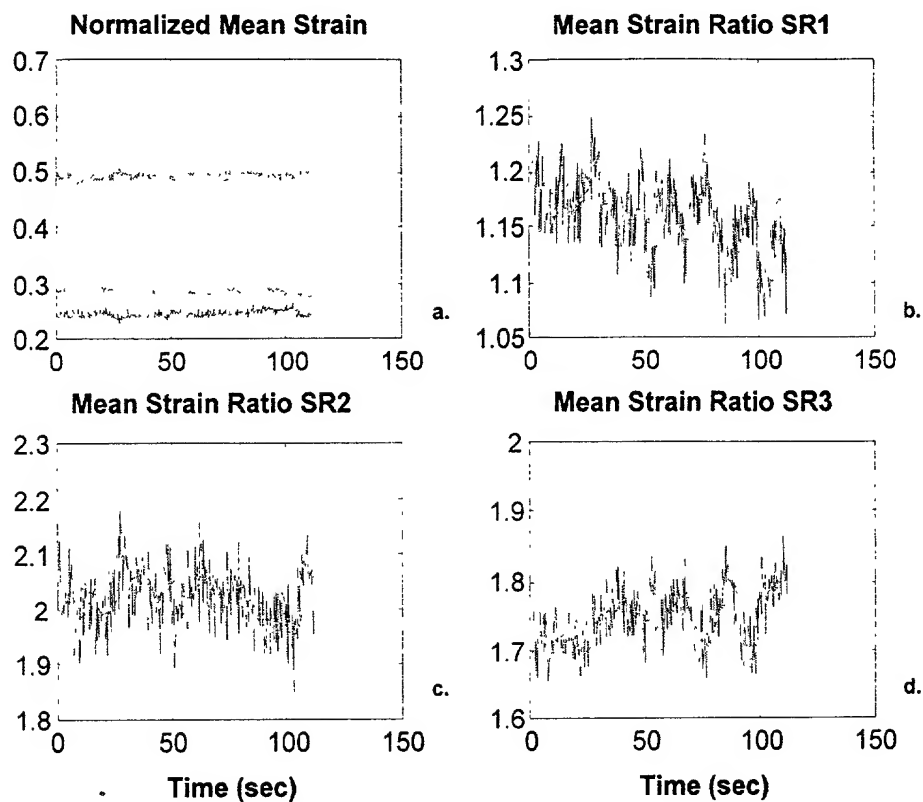


Figure 27

## Strain Gauge Signal with Bearing In Early Failure

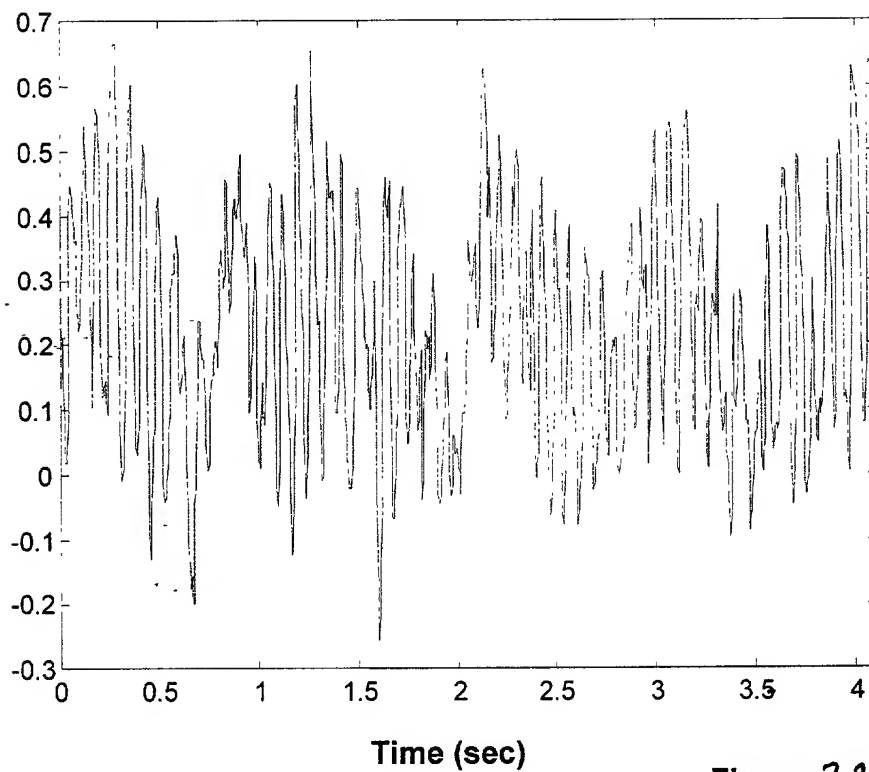


Figure 28

# Discrete FFT of Strain Gauge Signal for Bearing In Early Failure

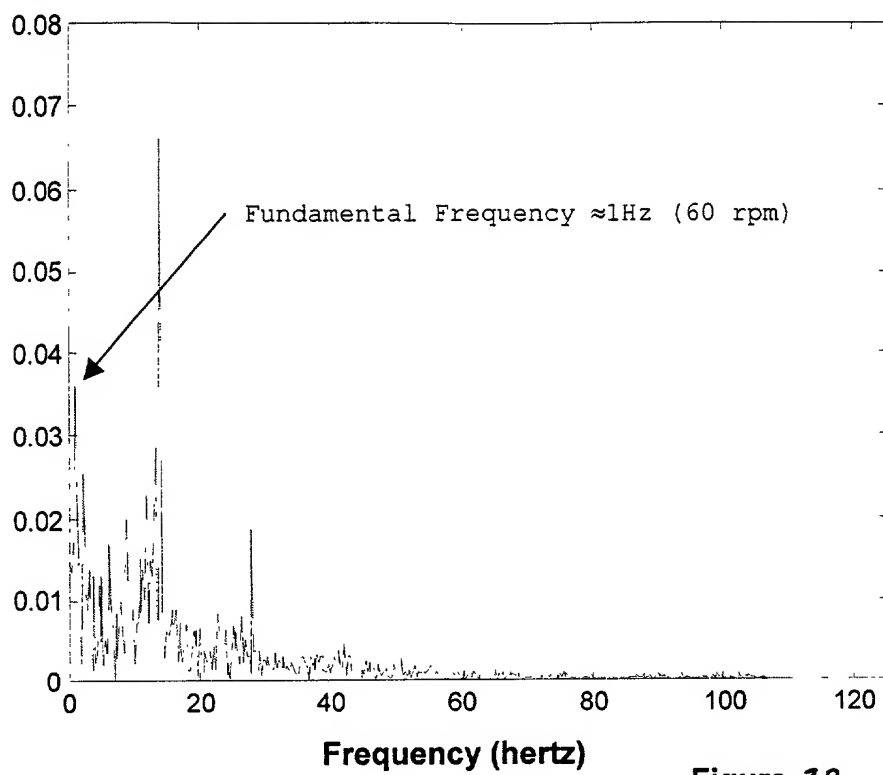


Figure 29

10036105-10101  
FOUO" 50T900T

Mean Strain Analysis for Bearing in Early Failure

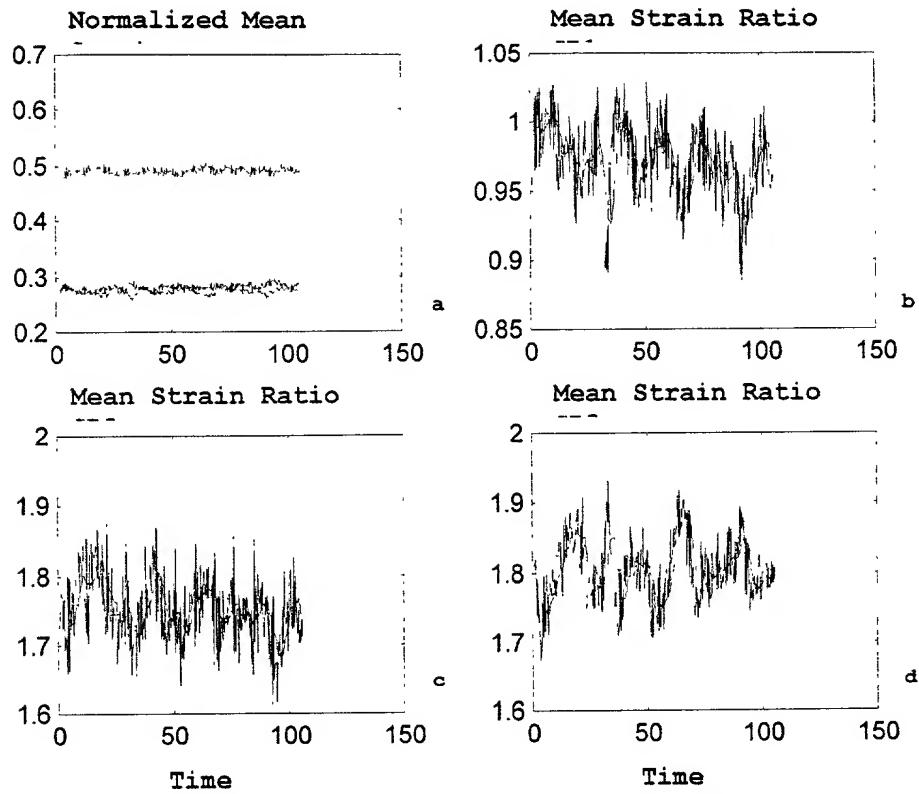


Figure 30.

10036105-10101  
TOTAL "SOT" 9200

# Mean Strain Analysis for Shifting Load Condition

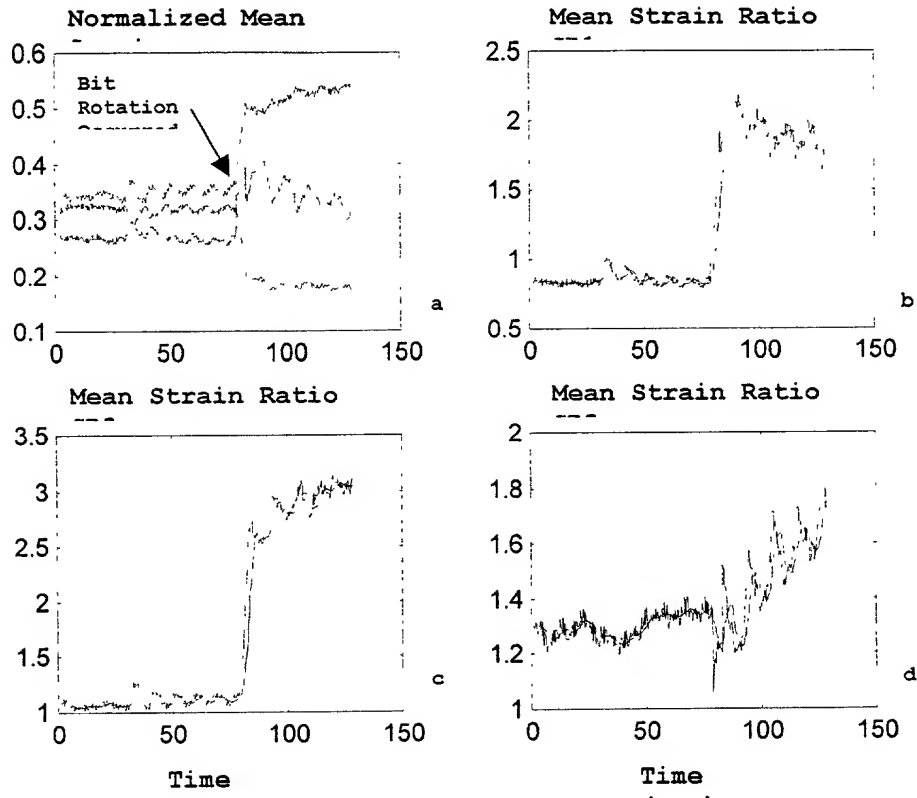


Figure 31.

10036105-10101

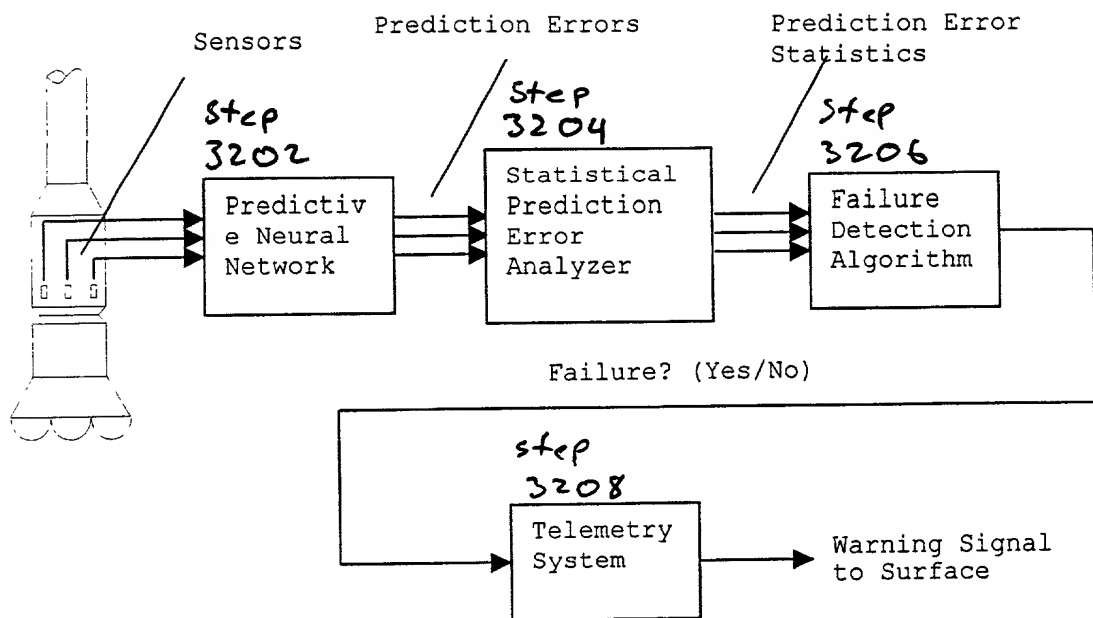


Figure 32 Schematic of ANNPA Bearing Failure Detection Scheme

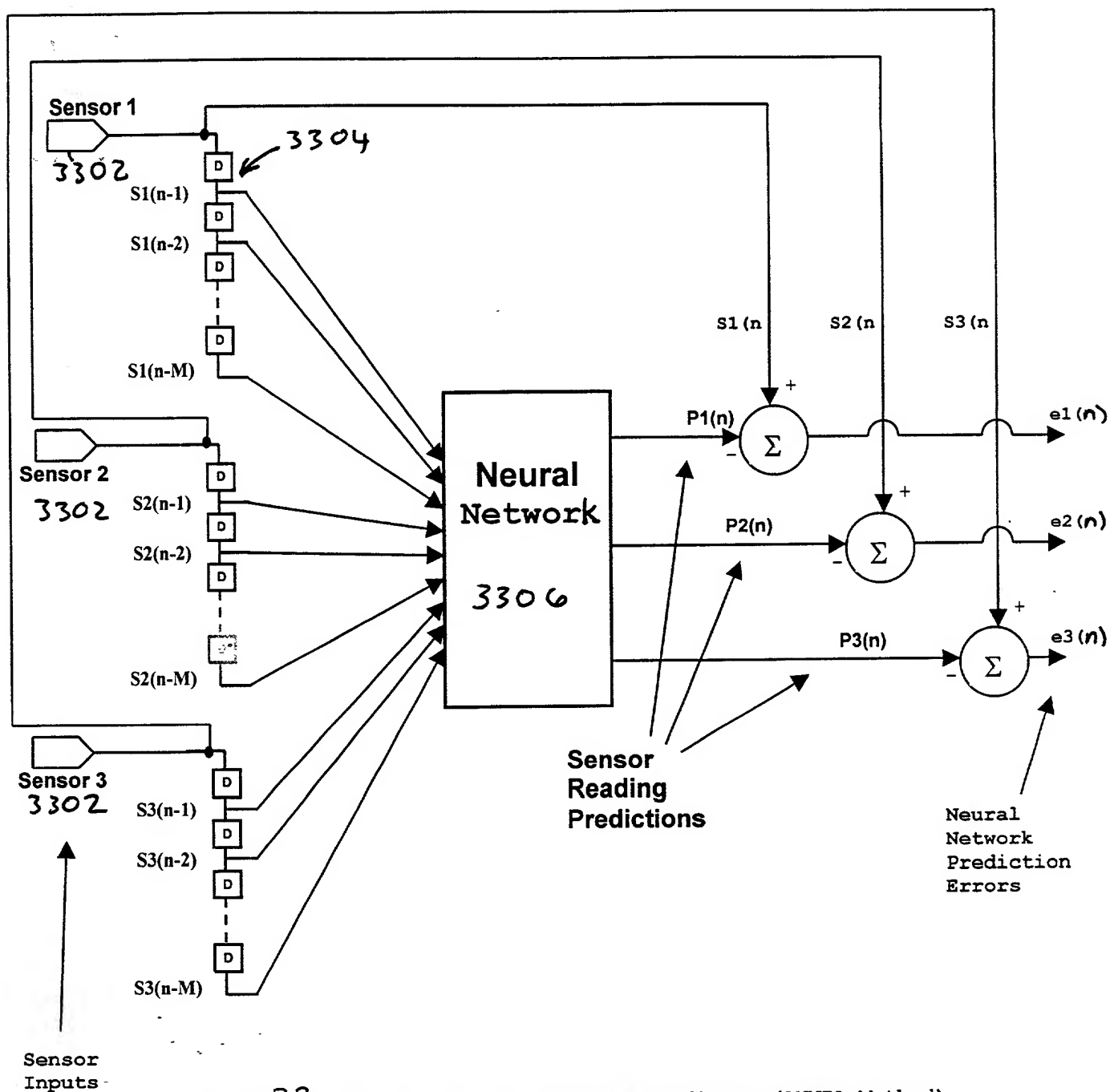


Figure 33 Adaptive Neural Network Predictor (ANNPA Method)

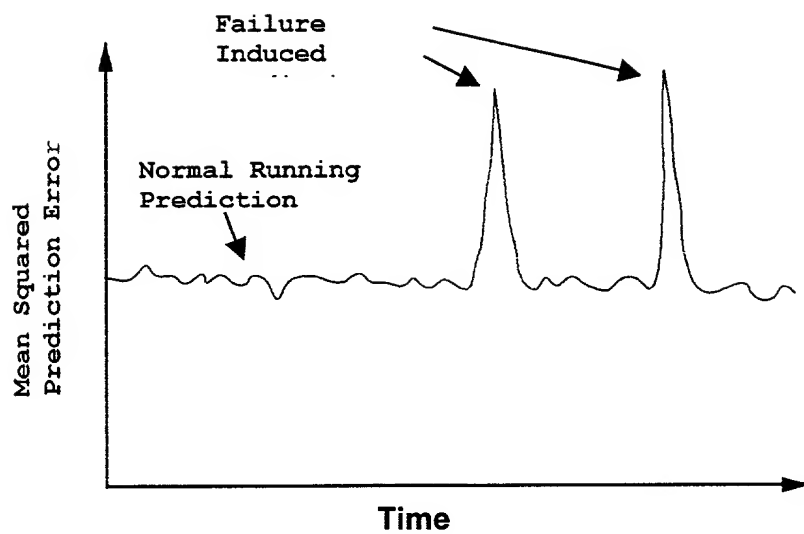


Figure 34 Failure Indications (ANNPA Method)

Acceleration (No Bearing Damage)

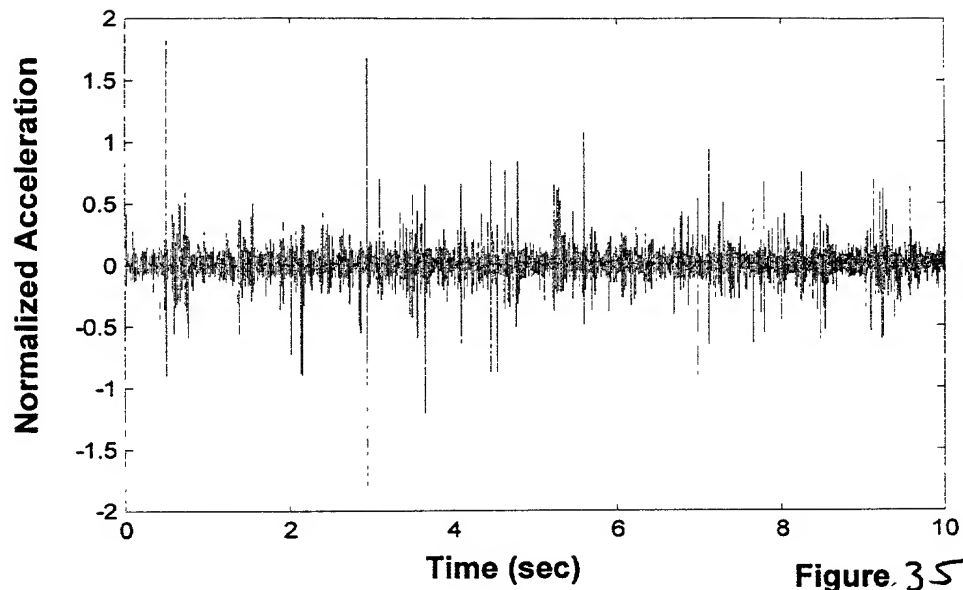


Figure 35

Acceleration Prediction Error (No Bearing Damage)

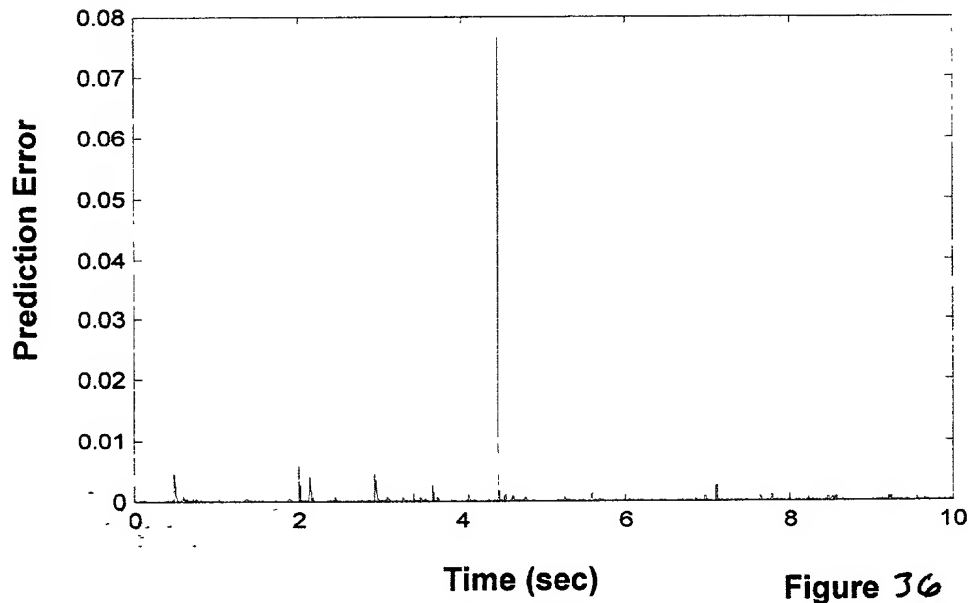


Figure 36



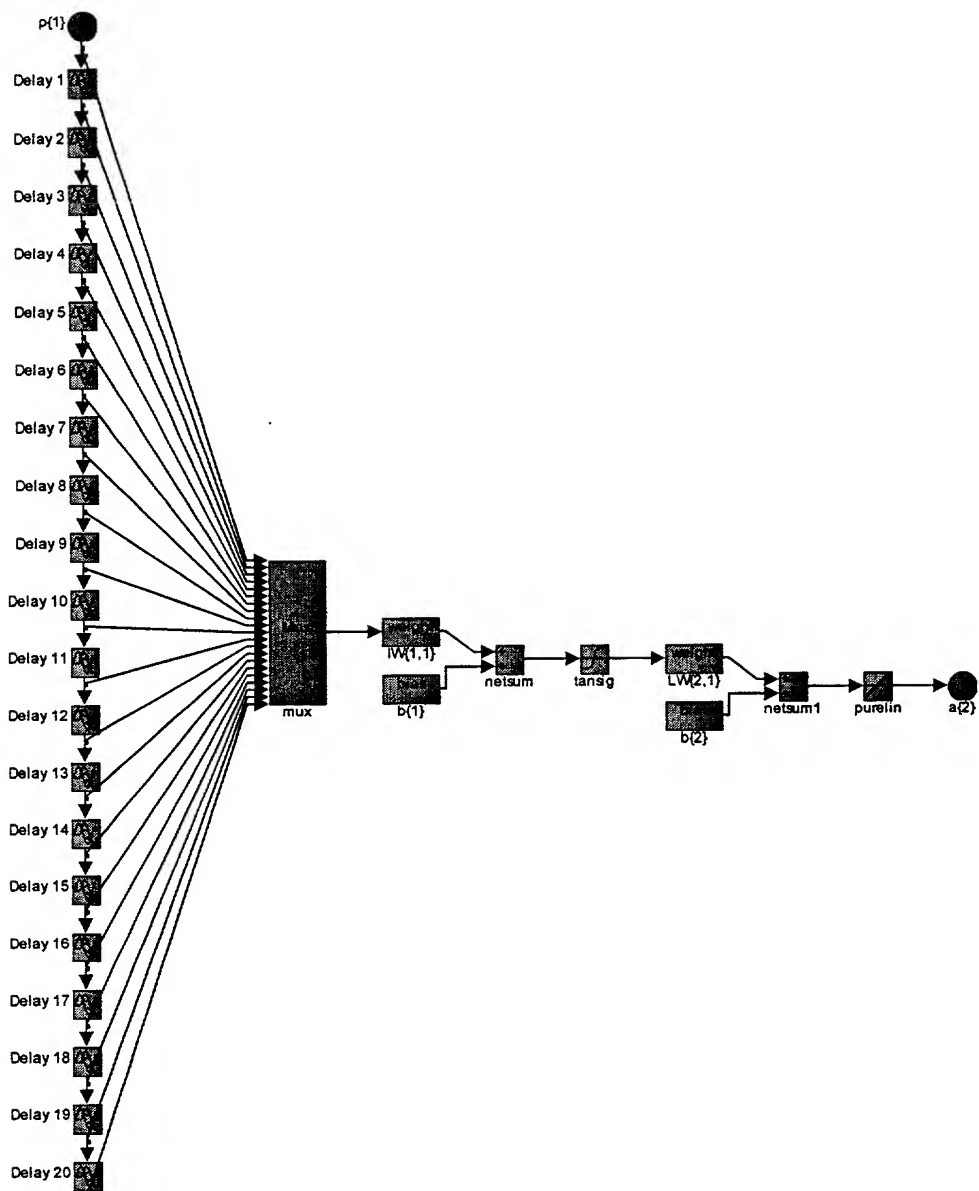


Figure 37

Acceleration (Light Bearing Damage)

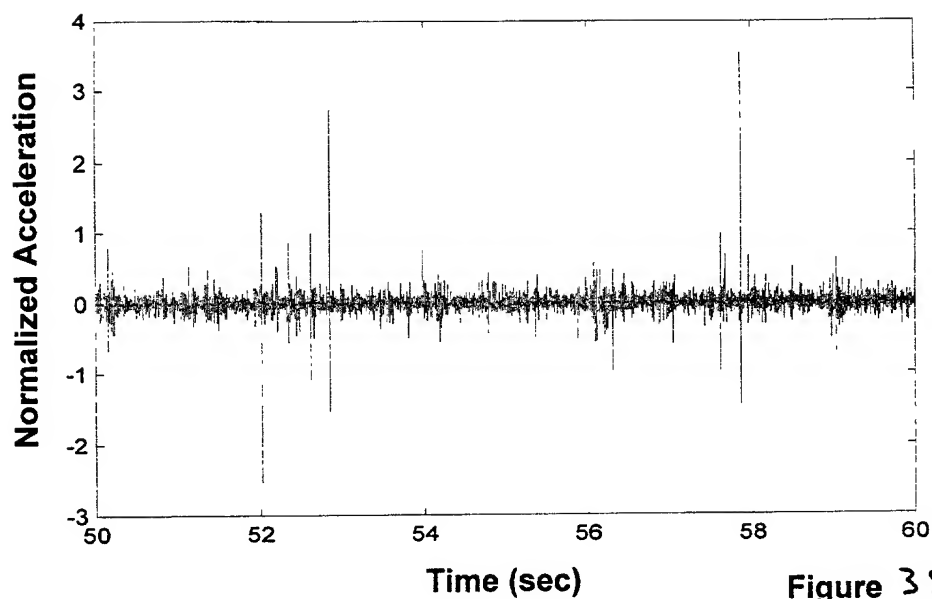


Figure 38

Acceleration Prediction Error (Light Bearing Damage)

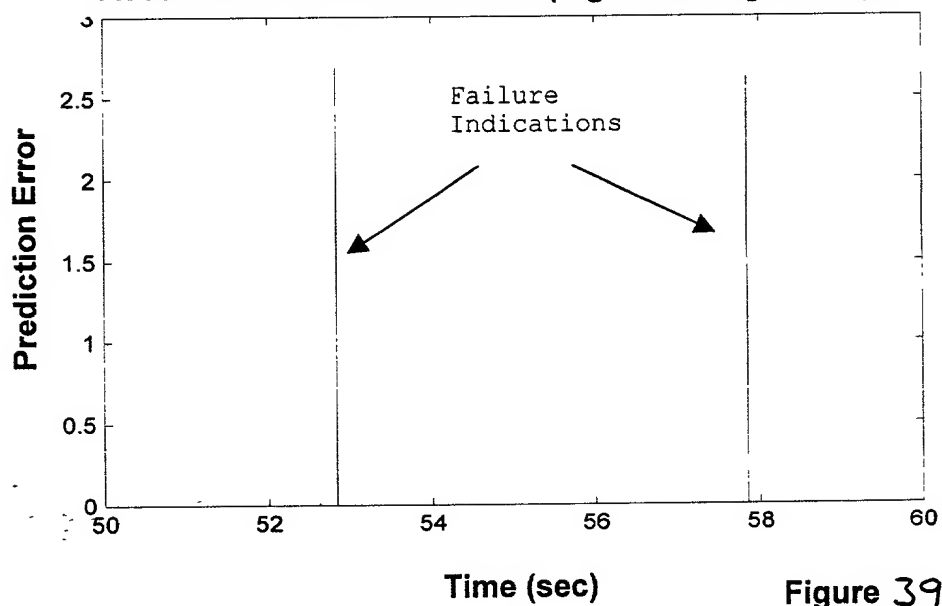


Figure 39

Acceleration (Moderate Bearing Damage)

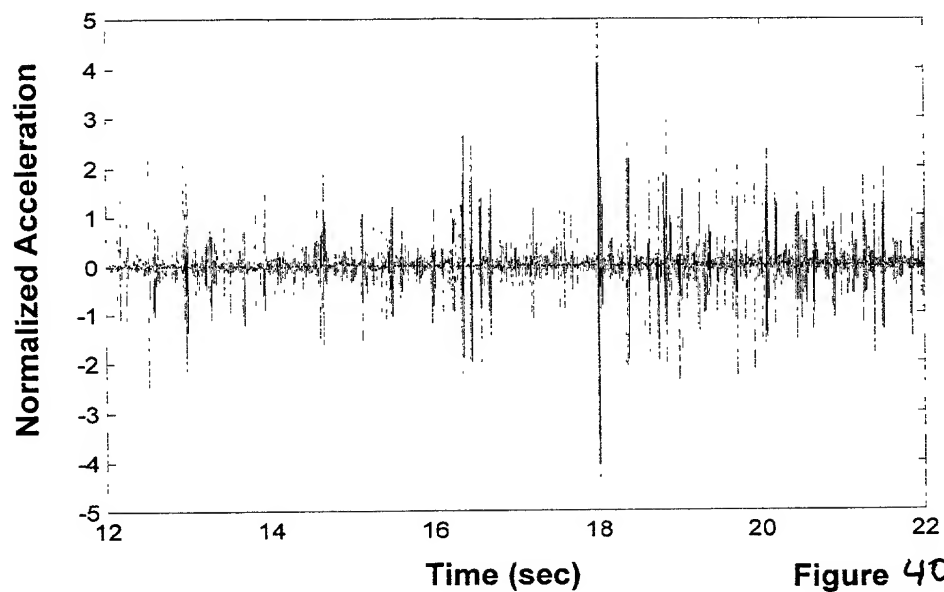


Figure 40

Acceleration Prediction Error (Moderate Bearing Damage)

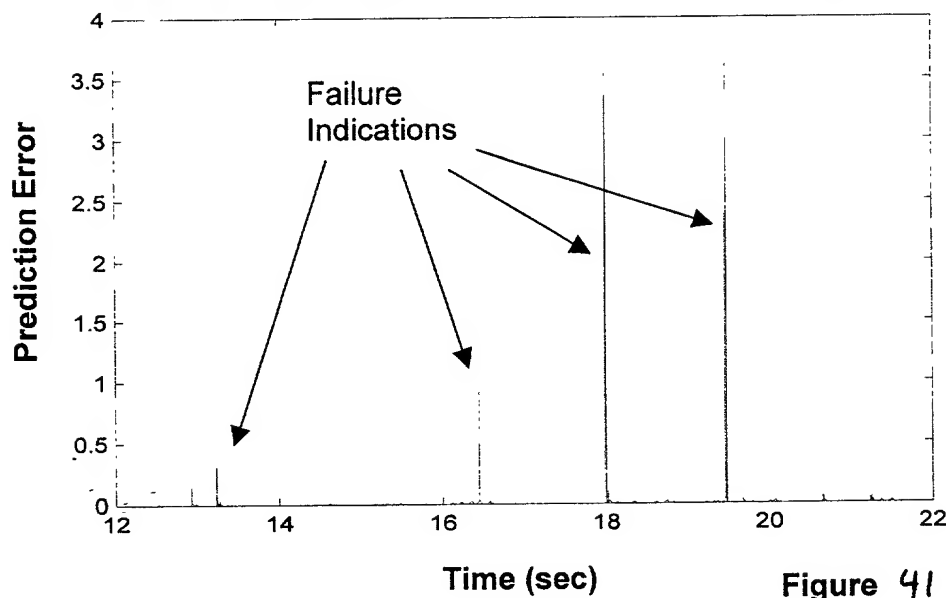
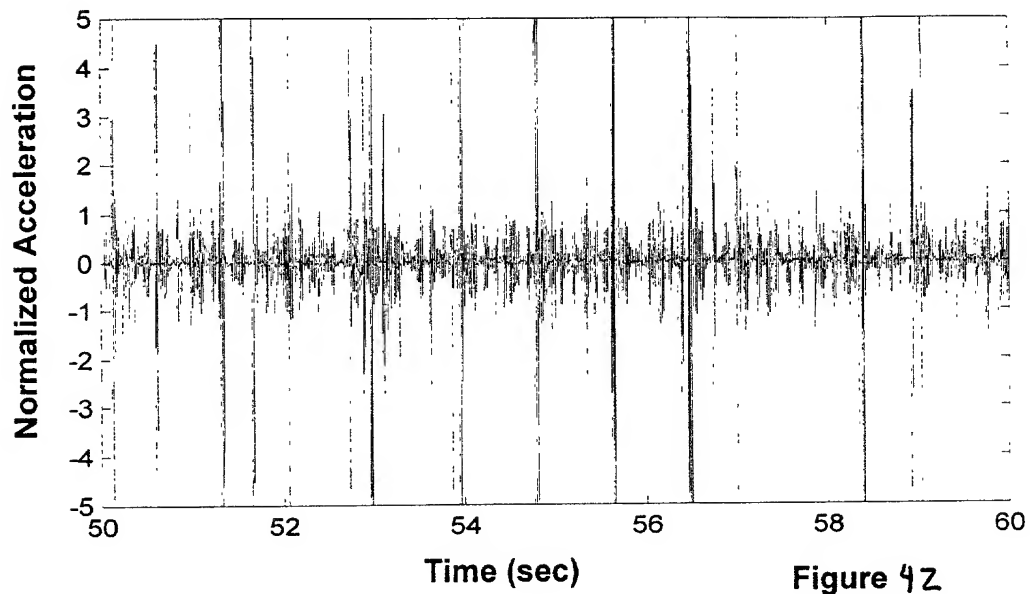


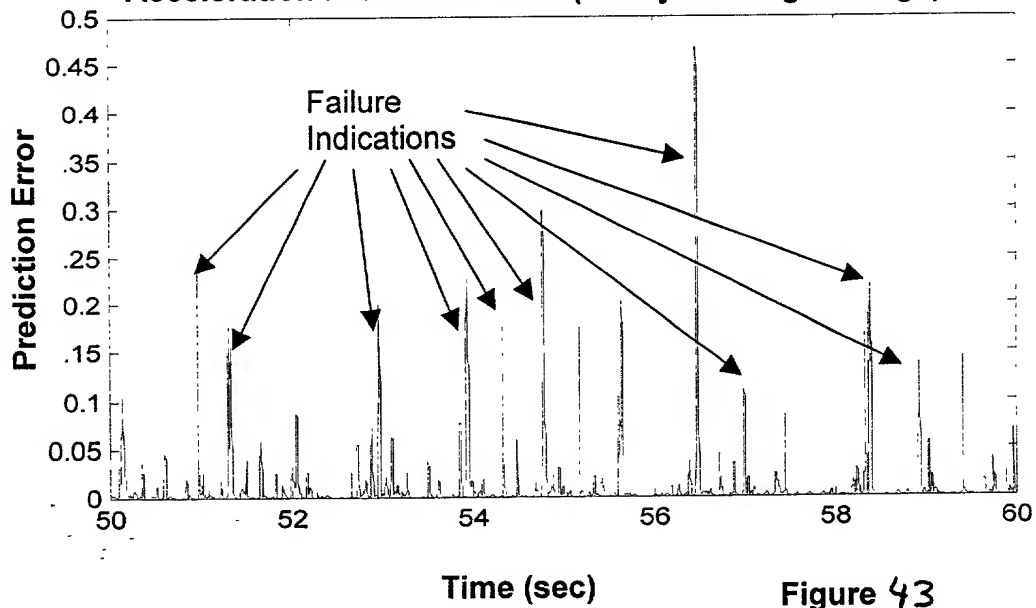
Figure 41

**Acceleration (Heavy Bearing Damage)**



**Figure 42**

**Acceleration Prediction Error (Heavy Bearing Damage)**



**Figure 43**

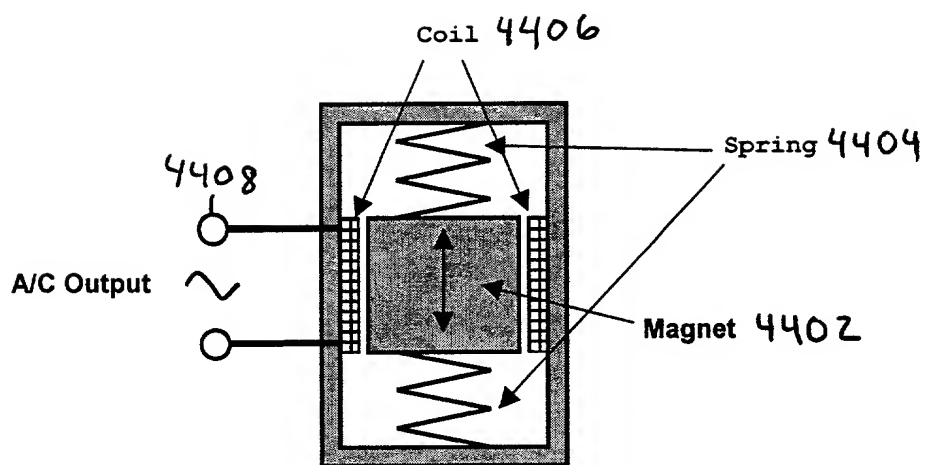


Figure 44 Diagram of Voice Coil Power Generator

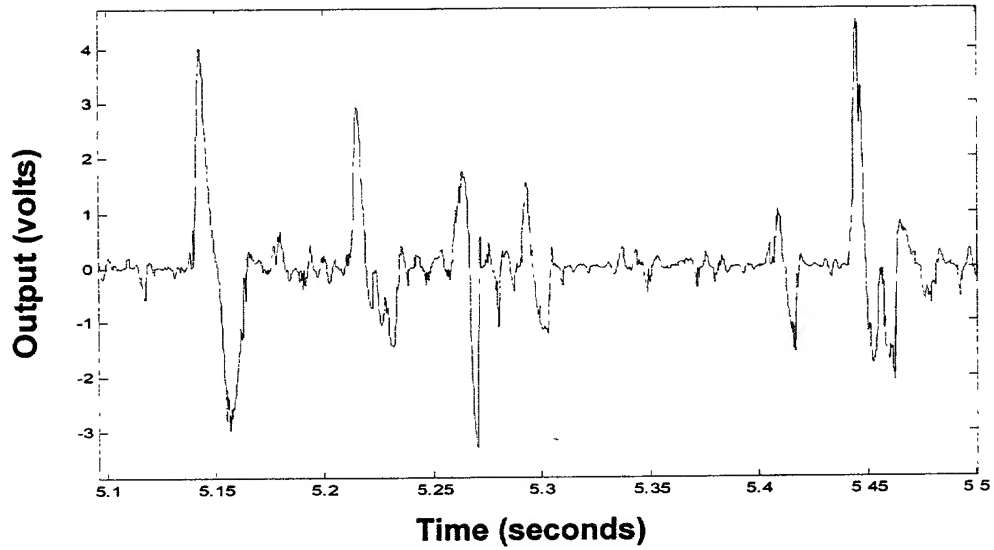


Figure 45 Scaled-Down Prototype Power Generator Output (1000  $\Omega$  Load)

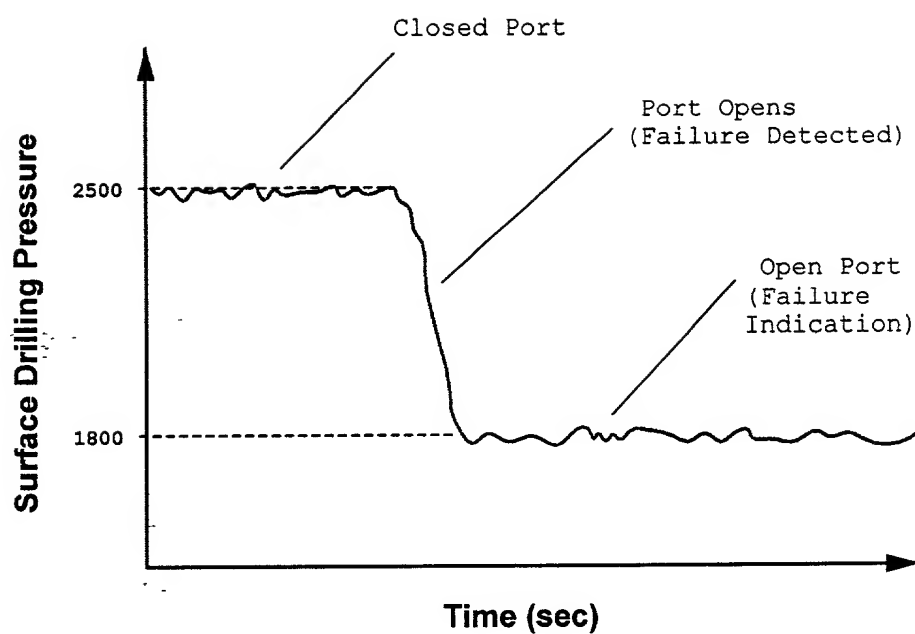


Figure 46 Open Port Failure Indication

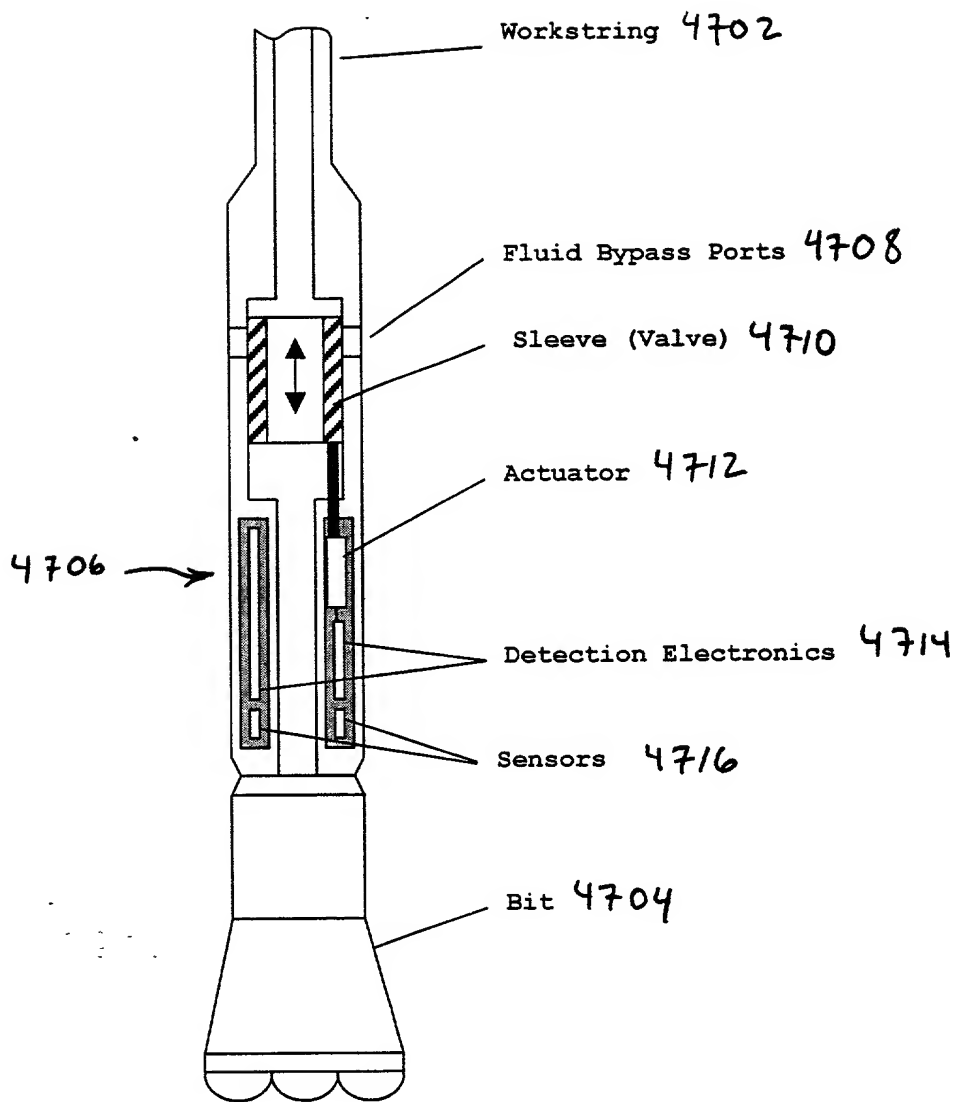


Figure 47 Downhole Tool Schematic



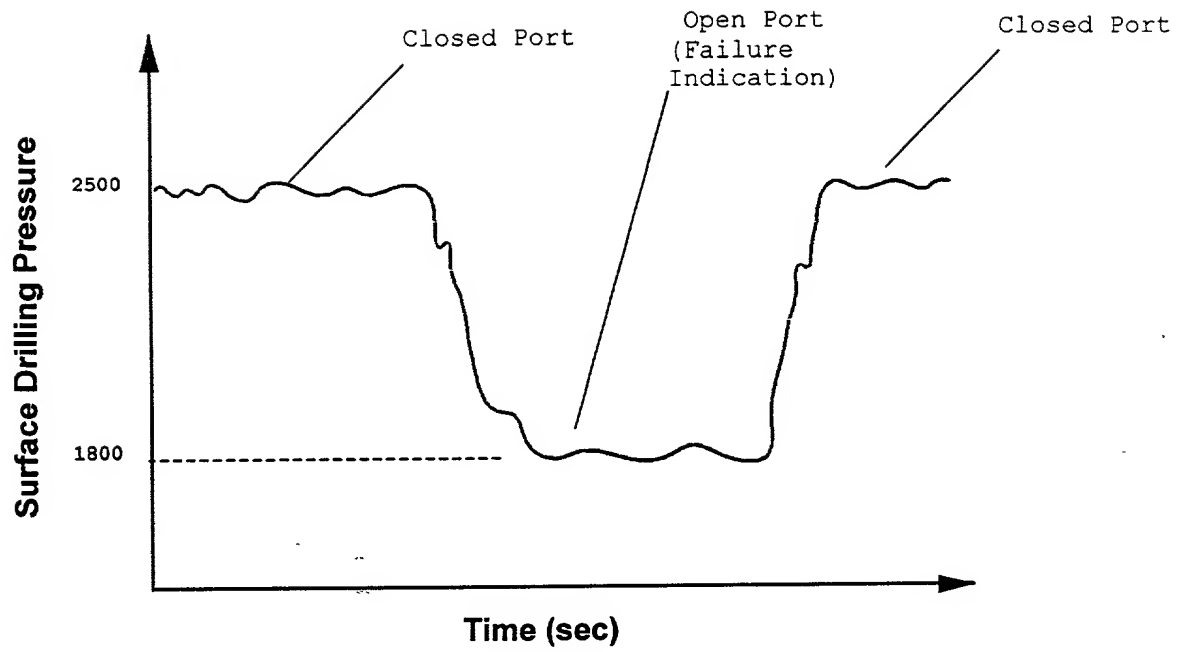


Figure 48 Open-Close Signaling Operation

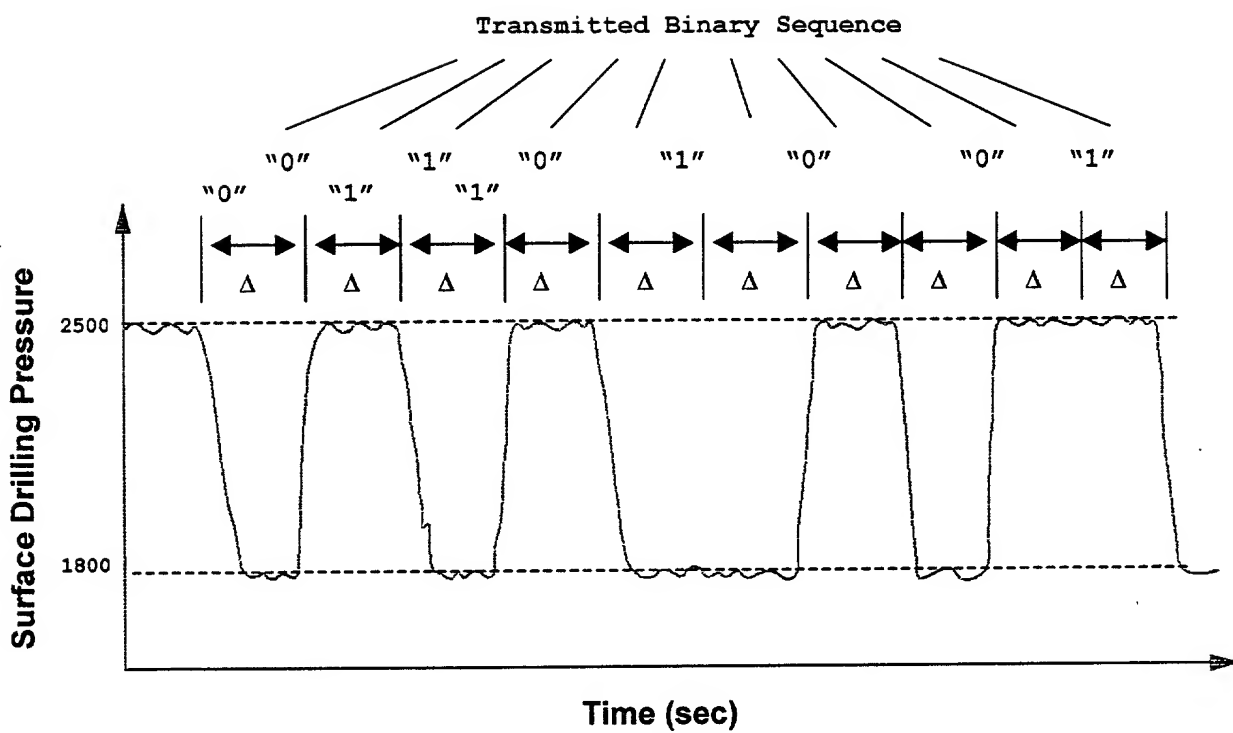


Figure 49 Binary Data Transmission Using Static Pump Pressure Levels

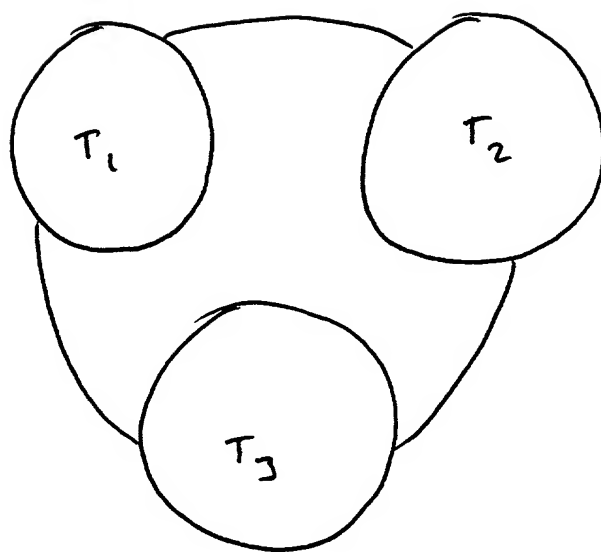


Figure 50

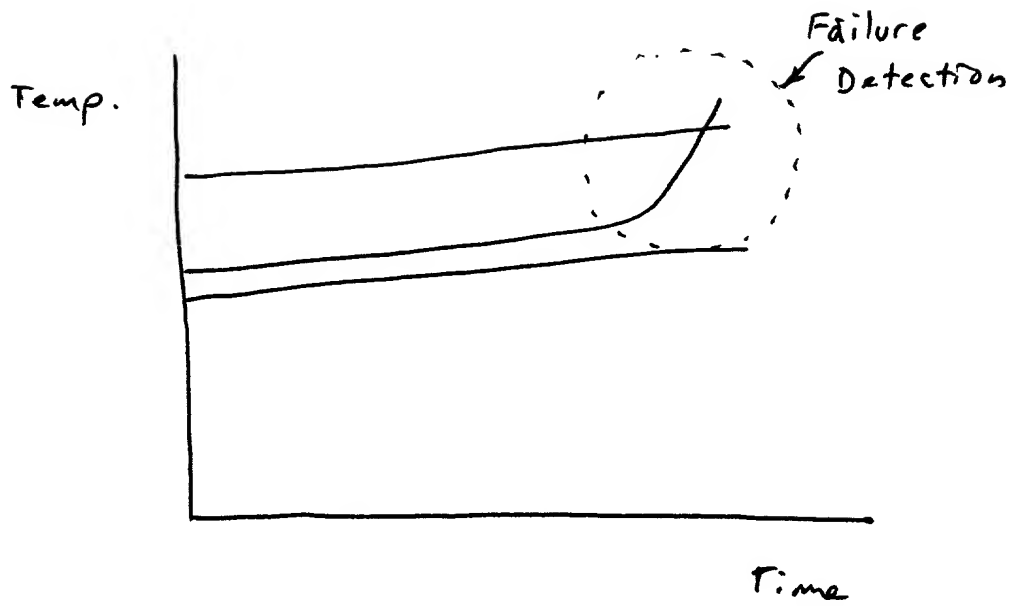


Figure 51

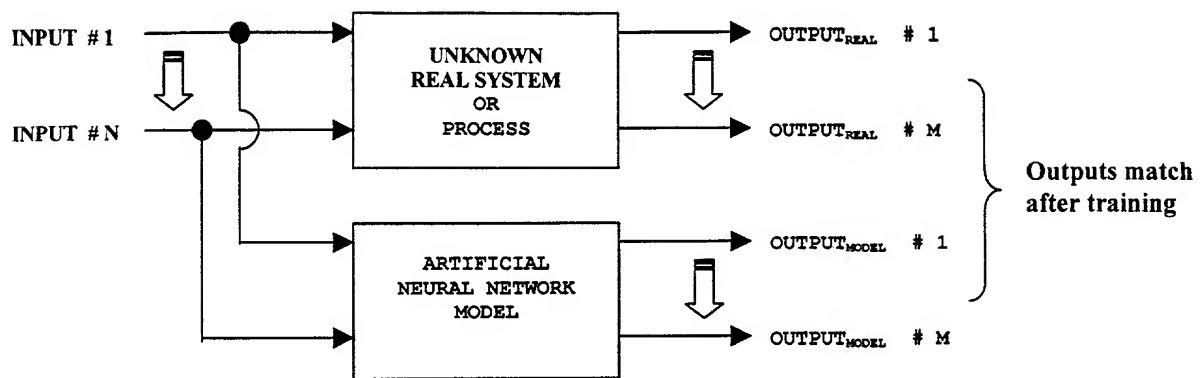


Figure 52 Neural Network Modeling  
Real System

TOP SECRET

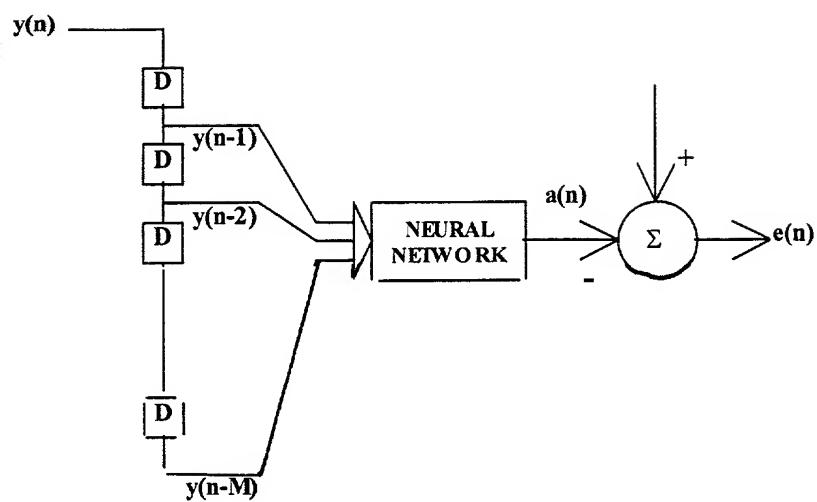


Figure 53

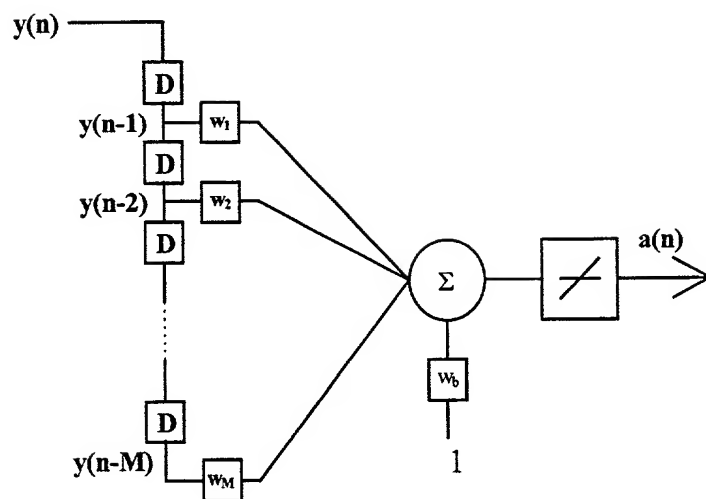


Figure 54 Basic Linear Network

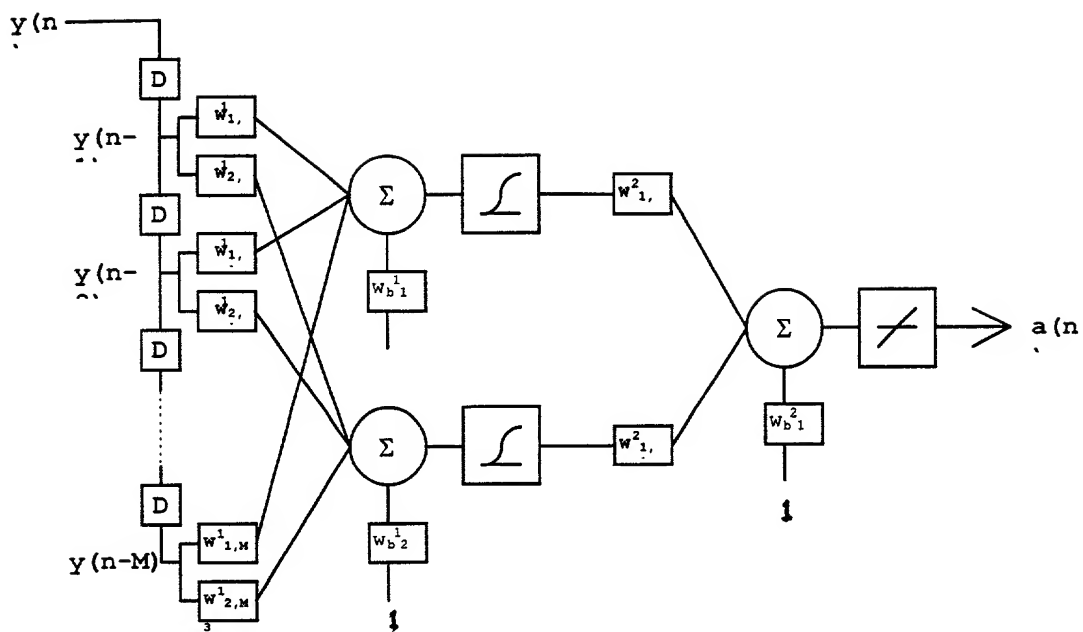


Figure 55



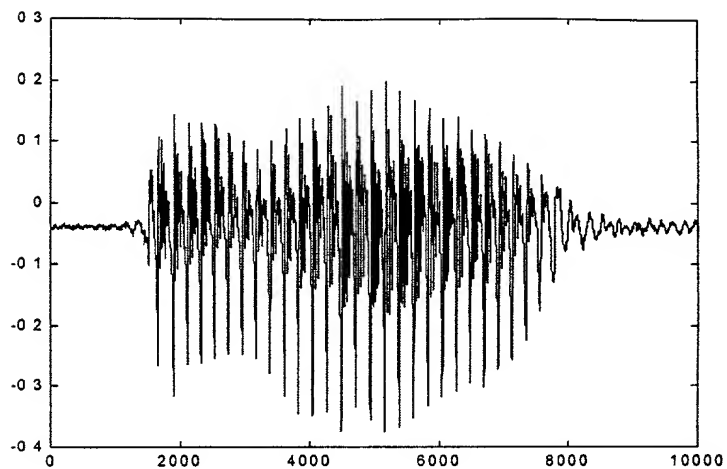
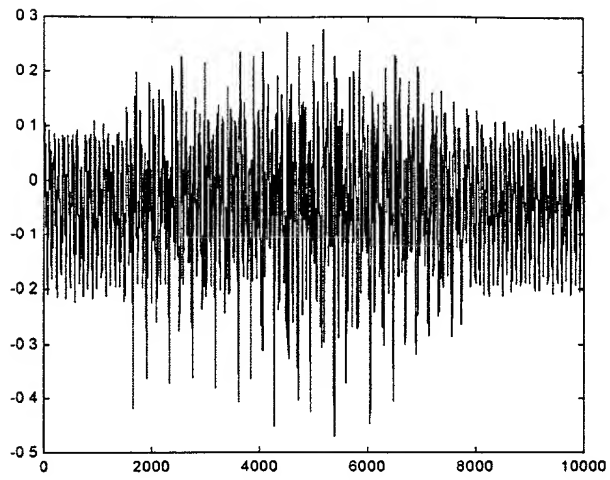
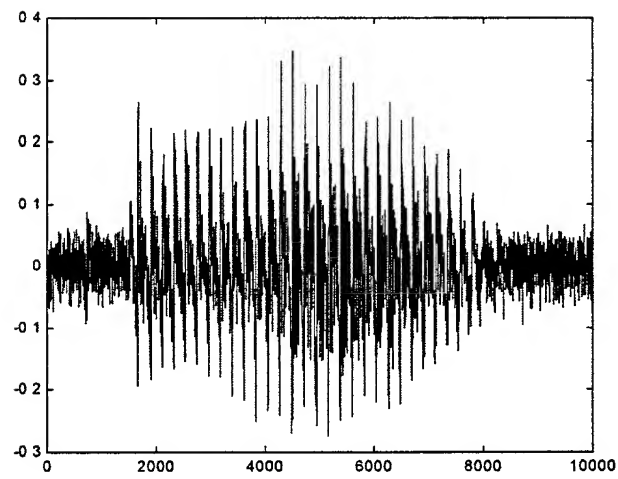


Figure 56

10036405-101701

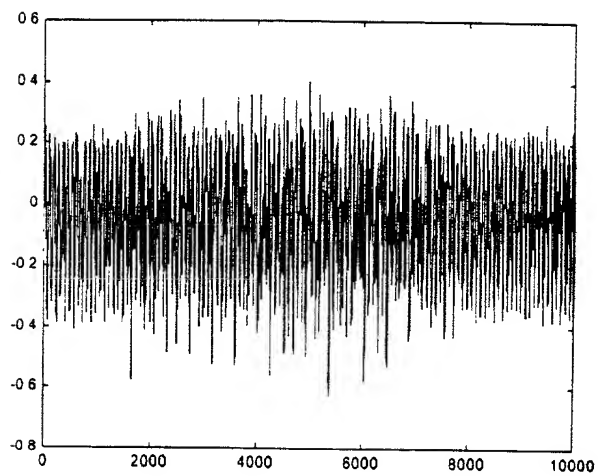


Corrupt Signal S/N Ratio = .95

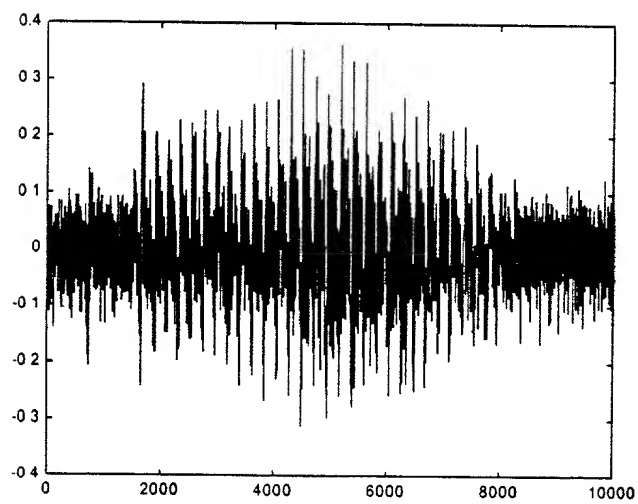


Filtered Signal S/N Ratio = 2.35

Figure 57



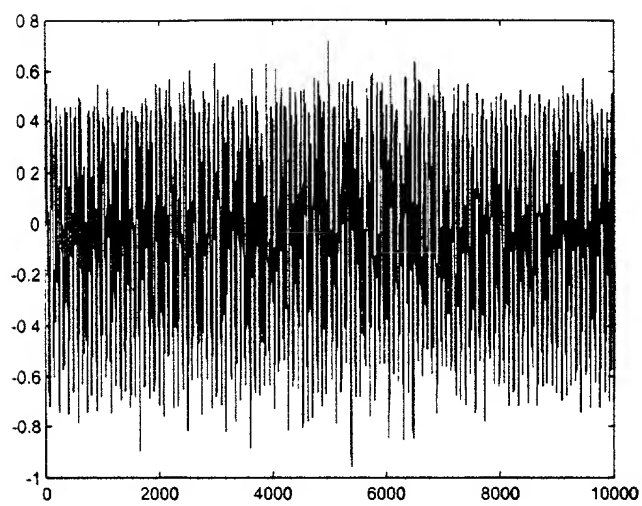
Corrupt Signal S/N Ratio = .24



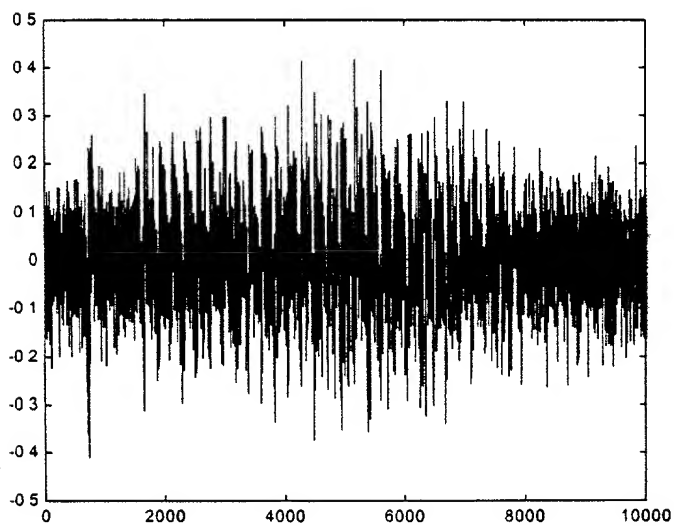
Filtered Signal S/N Ratio = 1.68

Figure 58

10036406-101701

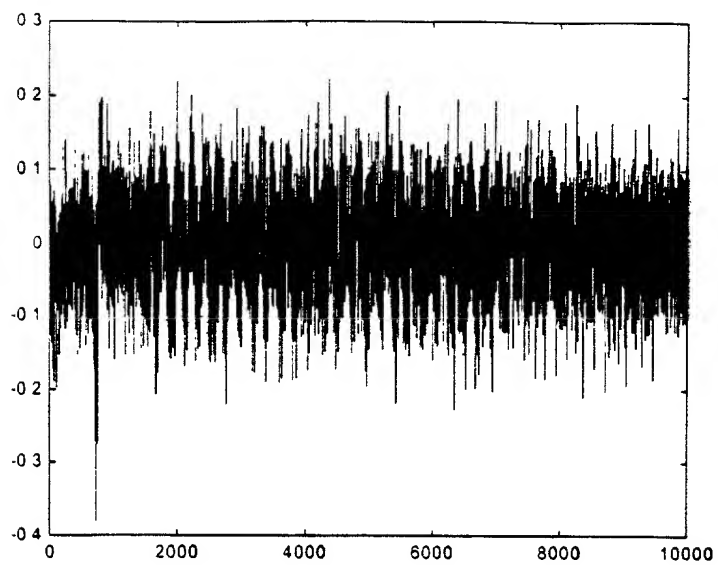


Corrupt Signal S/N Ratio = .06



Filtered Signal S/N Ratio = .89

Figure 59



Linear filter results. S/N = .7457  
Figure 60